ARAB REPUBLIC OF EGYPT
CABINET OF MINISTERS
EGYPTIAN ENVIRONMENTAL AFFAIRS AGENCY (EEAA)
DEPARTMENT OF NATURE PROTECTION
MedWetCoast Project

Lake Burullus:

Burullus Protected Area

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Professor of Plant Ecology
Faculty of Science,
Tanta University

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Professor of Aquatic Ecology
Faculty of Science,
Ain Shams University

Publication of National Biodiversity Unit. No. 13. 2005

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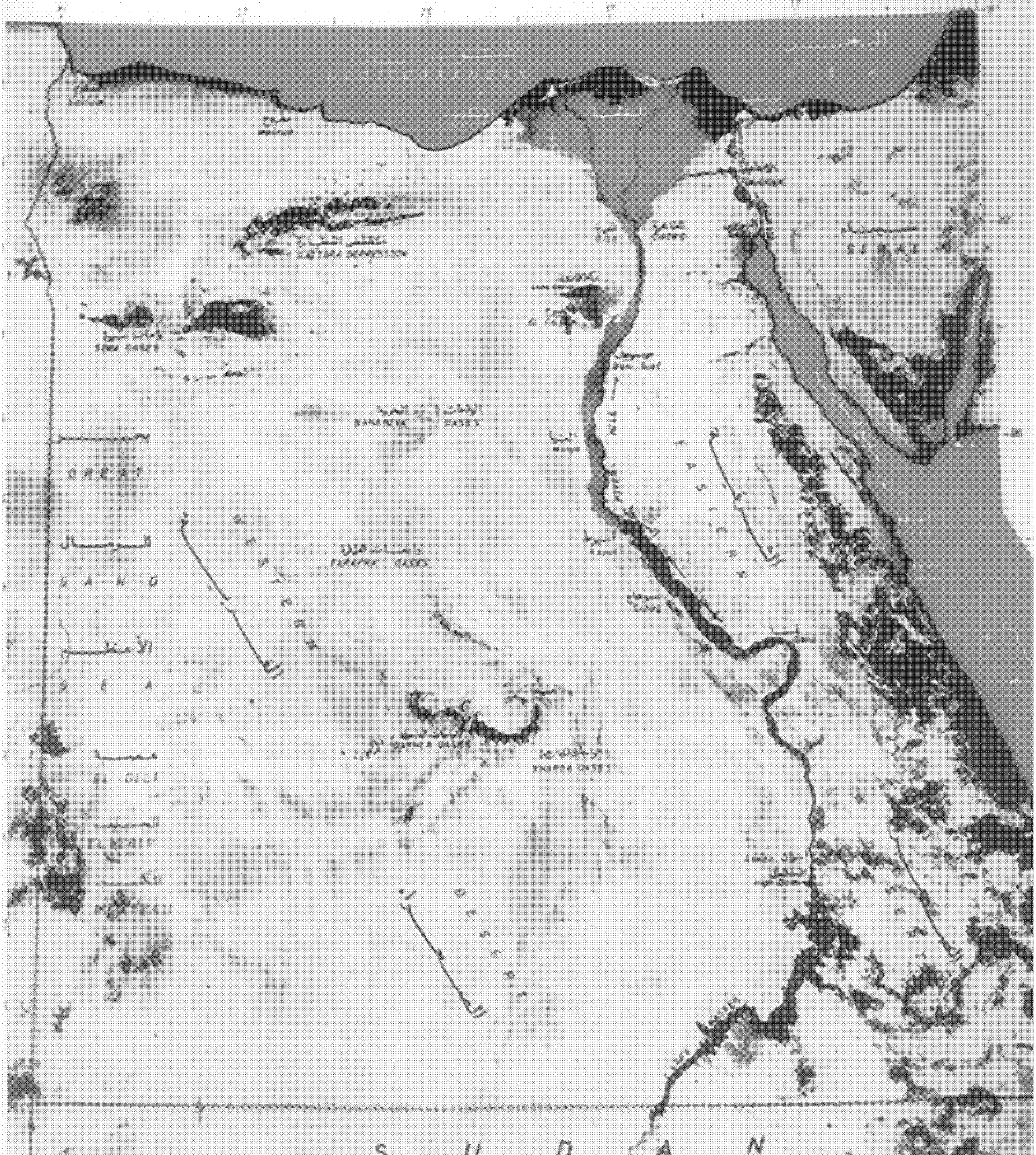
LANDSAT SATELLITE IMAGE
OF THE ARAB REPUBLIC OF EGYPT
FROM 950 Km ALTITUDE

صورة فضائية لجمهورية مصر العربية
من القمر الصناعي «لاندسات»
من ارتفاع ٩٥٠ كيلو متر



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The authors

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PREFACE

Lake Burullus, situated in a middle locus between the two branches of the Nile that form the Delta, is the centre-piece of the five lakes (and associated wetlands): Bardawil in Sinai, Manzala in the eastern Delta, Burullus, Idku in west and Mareotis further west. The chain of the five lakes stud the c 500 km coastal front crossed by flyways of migratory birds in their seasonal journeys between the Euro-asian palearctics and the African tropics, all are wetlands of international importance. This – most welcome – volume addresses the ecology and biodiversity of Lake Burullus and its resident and transient biota, and provides a rich depot of information relevant to the Lake and the communities that depend on its resources.

The authors, and their students, have been involved in ecological studies on Lake Burullus and other northern lakes of the Nile Delta during recent decades, and in the intensive surveys (diagnostic studies) carried out under the MedWetCoast-Egypt (since 2000), and in the subsequent studies towards setting management plans for conservation areas of these wetlands. By virtue of this long standing involvement the authors were fully cognizant of the so many studies (theses, papers, reports, etc.) addressing the biodiversity, ecology and economics of the Lake and its outskirting territories, and were actually involved in surveys and inventories carried out during recent years on Lake Burullus. This made them best qualified to collate and digest the rich and diverse volume of data on the Lake.

This volume has several merits. (1) It presents analyses of records of ecology and biodiversity of Lake Burullus and its associated habitats, and provides a rich base-line compendium that shows the elements that we know and the gaps that need to be filled. (2) Ecological analyses of these records provide bases for ecologically sound management of the Lake that ensures balance between needs of conservation of biodiversity and sustainable use of the life-support systems of natural resources of the Lake. 17000 fishermen (licensed and not) and their families depend on these resources for their living. (3) Assessments of impacts of human activities in the Lake and in the vast territories that form the catchment area of the Lake (drainage collected from all the Governorate of Kafr-el-Sheikh and beyond debouch onto the Lake) provide decision makers with bases for sound decisions and fair judgements. (4) The wealth of information contained in this volume makes it a rich source-book for environmental education at all levels, and for programmes of public awareness. (5) The data and illustrations on biodiversity will make this book a very useful tool in the hands of rangers and technicians working in the Lake Burullus Protectorate in the programmes of survey and monitoring.

The first three chapters provide information on the ecological (physical) features of the Lake including geomorphology, hydrology, water and bottom sediments features, etc. Changes that occurred in long-term history (geology) and in short-term history (the 20th Century) are envisaged on bases of historical records, mineralogical analyses of sediments and palynological studies of surface and deep cores. Likely impacts of future climate changes are noted. Chapters 4 – 8 and chapters 10 – 13 describe and analyse various taxonomic groups of living organisms and their habitat types. Wealth of information is most admirable. It presents a sum-up of what we know and clearly indicates what we need to know. Chapter 9 addresses fish diversity, ecological affinities and changes in response to changes in water. Fish taxonomy and ecology is closely knit with fisheries. The chapter provides a full report on fisheries: modes, methods, gear, production, etc. Because fishing is the principal occupation of the people of the Burullus area, this chapter is of a special significance.

Chapter 14 provides analyses of socio-economic set-up in the area, and shows the intimate relationships between society and the biological and ecological features described in the earlier 13 chapters. Chapter 15 summaries the plan set for management of the Burullus Protectorate. The plan gives the responsibility of implementation to local-government authorities headed by the governor of the region and to local non-governmental bodies. The Arabic summary is a welcome part of the work.

This is a compendium of valuable and useful knowledge about a wetland area of national and international importance. The authors well deserve praise and commendation together with the dozens of Egyptian and non-Egyptian scientists and scholars who contributed to the rich pool of ecological knowledge summed in this volume. The Egyptian Environmental Affairs Agency (EEAA), through its National Biodiversity Unit (NBU), made the compilation and publication possible and deserves special acclaim. This book is a sequel of an earlier volume (NBU, 11, 2000): Lake Nasser, it is hoped that subsequent volumes will cover other lakes and associated wetlands of Egypt.

M. Kassas

July 2005

Emeritus Professor of Plant Ecology,

University of Cairo.

FOREWORD

It gives me special pleasure to introduce this comprehensive treatise on "Lake Burullus": the lake and its outskirting territories. This publication is a part of our national endeavour in the fields of conservation and sustainable management of wetlands. Lake Burullus, by virtue of its position in the middle front of Nile Delta and on one of the principal flyway routes of international bird travel between the Palaearctics and Tropics, is a wetland formation of significance on the national and international scales. It justifiably deserves its inclusion in the Ramsar list of wetlands of world importance.

During the 20^{th} century, Lake Burullus and its outskirts have been subject to:

1- programmes of land reclamation that transformed extensive areas of the southern fringes of the lake into farmlands,
2- changes in the hydrology of the lake that caused the balance between salt water and brackish water to ebb towards brackish water prevalence,
3- the lake remains a major part of the fisheries of Egypt, but increase in fishing effort (due primarily to population increase) and in fish farming caused imbalances in productivity (increase of quantity but not quality),
4- completion of the River Nile management schemes caused imbalances between the shore-line processes of accretion and erosion, the net result was overall shore-line retreat,
5- extensive surveys and research studies on the lake, its habitats, biota, history, etc. have been carried out, some were published and others remained unpublished reports.

A principal purpose of this publication is to digest the rich volume of information contained in the wealth of disparate studies, assess the ecological changes and their impacts on biodiversity and on people.

The authors carried out their assignment with high-level of proficiency. Efforts invested in this endeavour are evident and commendable, and it is my pleasure to record my appreciation for a welcome volume that is informative and that provides guidance to steps in schemes of sustainable development of natural patrimony and conservation of biodiversity. The book will also provide useful reference for students of limnology and hydrobiology of Lake Burullus in particular and the lakes of northern Delta in general.

This is a particularly welcome contribution to the series of publications produced by the National Biodiversity Unit (NBU).

July 2005

Maged George Elias
Minister of State for the Environment

INTRODUCTION

Wetlands are of ecological importance due to their hydrologic attributes and their being ecotones between terrestrial and aquatic ecosystems. They are sometimes described as the kidney of the landscape because they function as downstream receivers of water and waste from both natural and human sources. They have been subject to transformation to drylands for agriculture schemes and human settlements, among others. River control schemes have often caused the loss, or area reduction of wetlands. The attributes of wetlands include high productivity, sources, sinks and transformers of numerous chemical, biological and genetic materials, and valuable habitats for fisheries, wildlife and birds. Conservation associations and bodies worldwide noted and described the alarming changes in these important habitats. This led to the Convention on Wetlands known as Ramsar Convention in 1971.

Definitions of wetlands are numerous and varied. The definition of U.S. National Academy of Science is: "a wetland is an ecosystem that depends on constant or recurrent shallow inundation or saturation at or near the surface of substrate. The minimum essential characteristics of a wetland are recurrent, sustained inundation or saturation at or near the surface and the presence of physical, chemical and biological features reflective of recurrent sustained inundation or saturation. Common diagnostic features of wetlands are hydric soils and hydrophytic vegetation. These features will be present except where specific physicochemical, biotic or anthropogenic factors have removed them or prevented their development". The international definition of Ramsar Convention is: "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt including areas of marine water, the depth of which at low tide does not exceed 6 meters".

The Burullus Wetland is one of the five northern lakes in Egypt. It is bordered from the north by Mediterranean Sea and from south by the agricultural lands of northern Nile Delta. This wetland is a Ramsar site and has been declared as a natural protectorate in 1998. The Protectorate includes the entire area of Lake Burullus with numerous islets inside it, as well as the sand bar separating the lake from the Mediterranean Sea, with a shoreline of about 65 km. It has an oblong shape extends for a distance of 47 km along NE-SW axis. Its width in the west does not exceed 5 km, then it increases in the middle to reach an average of 11 km. It is clear that Lake Burullus had lost about 62.5% of its size during the last two centuries (1092 km^2 in 1801 to 410 km^2 nowadays). Its depth varies between 40 cm near the shores and 200 cm near the sea outlet.

The marine bar (i.e. sand bar) of Lake Burullus is the zone that separates the Mediterranean coast in the north from the lake shore in the south. It covers an area of about 165 km^2. Although the surface of this bar is relatively flat, but it has different geomorphological features that had been formed upon it as result of the evolution and development of the geomorphological processes (sand flats, sand dunes and sand hillocks, salt marshes, tidal flats, sea outlet). Some of these features were related to the sedimentation process such as sand flats, sand dunes and sand hillocks; and some others were due to change of sea level like salt marshes and tidal flats.

Reed beds of Lake Burullus represent one of the most important reedbeds in the Mediterranean region, where this type of habitat is becoming rare and threatened. Wintering and migrant birds are strongly dependent on this habitat for foraging, refuge and breeding. Economically, the main activity in Lake Burullus is the fish production. Unfortunately, this lake is one of the major disposal areas for agricultural drainage water in Egypt. It receives most of the drainage water of Nile Delta that feeds the lake with about 4 billion m^3 annually (97 % of the total water input). On the other hand, the outflow to the sea contributes 80 %, while that of the evaporation contributes 16 %.

Lake Burullus had been the subject of many studies during the last three decades (1970 – 2000). More than one hundred and twenty theses, reports and papers had been published covering the geomorphology, morphometry, sedimentology, hydrology and water quality, macrophytes, microphytes and phytoplankton, zooplankton and zoobenthos, fishes and fisheries, avifauna and others (see Historical Review). The diagnostic studies of the Project "Conservation of Wetland and Coastal Ecosystems in the Mediterranean Region (MedWetCoast)", in 2000 and afterwards, have enriched and updated the available information and data about the abiotic and biotic components of Lake Burullus ecosystem. Unfortunately most of these scientific materials are either of limited distribution, unavailable or not accessible to many of the concerned personnel. This encouraged the authors to collect, organize and analyze these scattered information and data, and to incorporate their own recent studies, into one volume deals with the physical features and biotic components as well as the socioeconomy of Lake Burullus.

This volume includes an introduction, historical review and 15 chapters in addition to an Arabic executive summary. Each chapter is prefaced by a table of contents and ends by a summary and list of references, and in many chapters by plates of characteristic physical and biotic features. **The first chapter** includes the general properties of the Burullus Wetland such as the location, geology, morphometery, habitat types, hydrology, biotic community and climatology. The geology deals with the formation of Nile Delta, subsidence and coastal processes that affected the evolution of the lake. Morphometery

presents information about the shape, dimension and morphometric units of the lake, geomorphological features of the marine bar and morphometry of the lake islets. The major habitat types were described as well as the hydrology of the lake including the budget of water balance. The biotic community was reviewed based on the three major biotic components of the lake ecosystem: producers, consumers and saprotrophs. At the end of this chapter, the climatic data from three metereological stations inside the Burullus Wetland were analyzed.

The spatial and temporal variations of twenty water properties were analyzed in **chapter 2**. These properties were classified into four groups: physical and aggregate properties (temperature, transparency, water depth, salinity, chlorosity, pH and alkalinity), oxygen properties (dissolved oxygen, chemical and biological oxygen demands), dissolved salts (phosphate, nitrate, nitrite and silicate) and heavy metals (copper, iron, cadmium, lead and zinc). Correlation analysis was applied to assess the degree of association between these variables.

The nature of bottom sediments and sedimentation rates were reviewed at the beginning of **chapter 3**. After that, the spatial and temporal variations of ten sediment properties were analyzed (salinity, chlorosity, pH, organic matter, iron, copper, zinc, lead, cadmium and nickel). The correlation between these variables was calculated, as well as the correlation between the similar variables in the water and sediments to assess the significance of association between them.

The flora and vegetation of the lake proper, its islets as well as the sand bar that separates the lake and the Mediterranean Sea was the subject of **chapter 4**. An annotated checklist of the recorded species and their distribution among habitats are presented. The flora were analyzed in terms of life form, species diversity, phytogeography and abundance. In addition, an emphasis on the endemic, rare and noteworthy species was done. The economic importance of the recorded species was assessed in terms of grazing, fuel, medicinal, human food, timber and other uses. This chapter deals also with the problem of common reed (*Phragmites australis*) in the lake taking into account its spatial and temporal variations, water characteristics, nutritive values, economic uses and control techniques. On the basis of the palynological studies, the ancient flora and vegetation in Burullus Wetland were envisaged.

In **chapter 5**, the phytoplankton was analyzed in terms of species diversity, density and biomass of the three major algal divisions (Bacillariophyta, Chlorophyta and Cyanophyta). The epiphytic algal species on the common submerged hydrophyte *Potamogeton pectinatus* were listed. At the end, this chapter presents a comparison between the phytoplankton of Lake Burullus and that of some North African lakes.

Although the studies on the aquatic bacteria and fungi in Lake Burullus are too limited, both biotic groups are described in **chapter 6** based on only two recent publications. This chapter includes a review on the saprotrophism and the oxidized microzones of the bottom sediments in the water bodies, in addition to the actinomycetes and zoosporic fungi in Lake Burullus. Zooplankton and zoobenthos were the subject of **chapters 7 and 8**, which evaluate the present status of the zooplankton and benthos biota (common, rare, disappeared and endemic species, as well as the new records). The seasonal variations of the common species were assessed as well as their population dynamics with emphasis on the eutrophication-indicator species and salinity indicator species.

Lake Burullus is one of the important fisheries in Egypt as it produces ca. 60,000 ton per year (census 2004). **Chapter 9** includes valuable information about the fishes and fisheries of this wetland. This includes the present status of fish species in terms of common, rare, very rare and disappeared species. It includes also, a brief description of 22 fish species including the Latin names, synonyms, common names, status, local and world distribution, biology and ecology, colour and economic importance. The change in fish production from 1963 up to 2003 is also included. The fisheries were reviewed in terms of the biology of the common cichlid and mullet species, fishing gears and techniques, and fishing effort analysis. At the end, the main threats to fisheries of Lake Burullus were diagnosed and recommendations for fisheries management were reported.

Chapter 10 includes detailed information about the first study on Arachnida and insects of Burullus Wetland. It includes species diversity, status of each species, its density and preferable habitats. **Chapter 11** deals with the amphibian and reptilian fauna, it contains systematic list for the recorded species taking into account the systematic position, common name, local and world distribution, preferable habitat, ecology and status of each species. **Chapter 12** includes the habitat types supporting important water birds in Lake Burullus, breeding birds, and bird surveys. An annotated checklist of the birds recorded during several bird surveys are presented, in addition to tables that include the status, abundance, national and world distribution of the recorded bird species. An emphasis was done on economic importance of bird species such as waterfowl hunting and capturing of the birds of prey. This chapter was ended by some useful management practices that were needed to apply in Burullus Wetland for conserving such important biotic group. **Chapter 13** includes a list of the recorded mammalian fauna with focusing on the acceptable Latin names, common names, observation localities in Burullus, national and world distributions, brief morphological descriptions, comparisons with the nearest species, types of habitat and ecology, with remarks from the previous literature.

Chapter 14 deals with the socio-economic development. It includes glimpses about the history and importance of Burullus Wetland, environmental setting, demographic development, economic activities such as tourism, agriculture and fisheries (economics of fishing, livestock, reeds and bird catching). This chapter includes also the results of a recent survey about education status and fishing activities such as number of sons practicing fishing, ownership of fishing boats, number of employees on fishing boats, average age of employees, number of fishing days, membership in fishing cooperatives, problem facing fishing and the proposed solutions.

The management plan for Burullus Protectorate Area was the subject of **chapter 15**. The document of this plan was prepared by the MedWetCoast Project; includes 5 main parts: background, site description, evaluation and objectives, implementation and plan of action. As the first two parts (background and site description) are presented in more details in the previous chapters of the present book (1-14), chapter 15 deals only with the evaluation and objectives (first evaluation, ideal objectives for the site, constraints or modifiers, second evaluation and operational objectives), implementation (management strategies, zoning and prescriptions) and plan of action (management action plan, programs and objects).

As the authors are aware, the present volume is an attempt to collect, organize and analyze available data and information about Lake Burullus, in a manner that may help the decision markers, conservationists, economic and environmental planners who are responsible for development and management, researchers, and even the students of biology and agriculture. It is hoped that the executive Arabic summary at the end of the book will offer a scientific information to a broad sector of the Egyptian and others interested in this wetland site.

The authors

HISTORICAL REVIEW

The review of literature on the studies that have been carried out on the physical, biological and socioeconomic characteristics of Burullus Wetland during the 3 decades (1970 to 2000) indicates the presence of some 126 papers, theses and reports (see Bibliography). They are classified under the following topics: geomorphology and morphometry (12: 1979 -1999), sedimentology (17: 1984 -1995), hydrography and water quality (17: 1974 - 1997), macrophytes (9: 1988 - 2000), microphytes (9: 1982 -1993), zooplankton and benthic fauna (5: 1977 -1995), fish and fisheries (33: 1971 -1998), avifauna (10: 1981 - 2000) and miscellaneous (15: 1971 -1999). As indicated in the bibliography, there is a plenty of studies on fish and fisheries, while the studies on the other biota are not common, particularly those on zooplankton and benthic fauna.

The available studies on the geomorphology and morphometry of Lake Burullus provide bases for a good picture on the recent geomorphological variations and factors that affect the lake. These studies include modern techniques such as remote sensing (e.g. Hussian 1994, Abdel Rahman & Sadek 1995) and geographical information system (El-Bayomi 1999). Other studies dealt with the characteristic features of the coastal sand formations of this region (e.g. El-Fishawi & El-Askary 1981, Khalifa 1982), beach accretion and erosion (Anwar *et al.* 1979) and coastal changes along the sides of sea outlet (Shereet 1990).

The sedimentological studies cover both the ancient (Nawar 1987, Selim & Zazou 1987, Abdou & Zazou 1989, Stanley *et al.* 1992, Arboille & Stanley 1994) and recent bottom sediments (Saad 1988, Badr 1990, Abdel Moneim 1995) in Lake Borullus with emphasis on the mineralogy and metal pollutant levels (e.g. El-Mamoney *et al.* 1988, Gheith *et al.* 1992, Mamdouh *et al.* 1992).

The hydrography and water quality studies dealt with water chemistry (e.g. Abdel-Moati *et al.* 1988), water heat balance (e.g. Maiyza *et al.* 1991, Said 1992), water pollution (e.g. Beltagy 1985, Mahmoud & Beltagy 1988), heavy metals (Darrag 1985, Abdel-Moneim *et al.* 1990, Abo-Waly *et al.* 1997), water exchange between the lake and sea (Abo-Zied 1980), desalinization of the lake water (El-Shrief 1993) and detergent refuses (Mahmoud & Beltagy 1988).

The distribution of the hydrophytes in Lake Burullus was studied by Samaan *et al.* (1988). This lake is characterized by extensive growth of

hydrophytes particularly along its eastern and southern shores beside the mouths of the drains. The dominant submerged plant was *Potamogeton pectinatus*, while *Potamogeton crispus* and *Ceratophyllum demersum* were less frequent, and *Najas armata* was of very limited distribution. The dominant emergant plant was *Phragmites australis* and, to some extent, *Typha domingensis* which grow well around the margins of the lake and islets. Floating plants *Eichhornia crassipes*, *Lemna gibba* and *Spirodella polyrrhiza* appeared also beside the mouths of the drains where their growth was enhanced by the flowing of fresh water.

The environment, flora and vegetation of Lake Burullus site had been studied, as a part of the north Nile Delta, by Al-Sodany (1992, 1998), Shaltout *et al.* (1995) and El-Kady *et al.* (2000). In a comparative study on the plant life of Burullus and Manzala lakes, Khedr & Zahran (1999) reported that Lake Burullus is floristically richer (135 species, 41 families) than Lake Manzala (102 species, 36 families), although Lake Manzala has two times larger area than Lake Burullus. They mentioned also that the islets of Lake Burullus seem to be a suitable habitat for some plants absent from the islets of Lake Manzala (e.g. *Lycium schweinfurthii, Pancratium maritimum, Allium roseum, Silene succulenta, Asparagus stipularis* and several annuals). Some plant species recorded in one site in Lake Burullus such as *Ipomoea imperati and Limonium narbonense* are rare, thus considered as threatened species and may need conservation measures (see also Khedr 1999, Khedr & Lovett-Doust 2000).

The studies on the microphytes (i.e. phytoplankton) cover the species diversity and standing crop biomass of the major algal groups such as diatoms (e.g. El-Sherif *et al.* 1989, Zalat & El-Sheekh 1999), cyanophytes and chlorophytes (e.g. Kobbia 1982, Samman *et al.* 1989, El-Sherif 1993). Some other studies were carried on the epiphytes attached on the most dominant submerged hydrophyte *Potamogeton pectinatus*. Some 45 algal species were recorded, most of them are limnetic forms, but can survive both planktonic and attached conditions (Samman *et al.* 1988).

Some early studies had been carried out on the zooplankton and benthos of Lake Burullus (e.g. Zazou 1977, Aboul-Ezz 1984). Samman *et al.* (1989 a) studied the community composition and distribution of the total benthic fauna in Lake Burullus, while Samman *et al.* (1989 b) studied the distribution and periodicity of some common species of zooplankton and benthic fauna. A paper was published on Lake Burullus in 1995 by Aboul-Ezz (1995), contained data recorded in 1979 and 1989. The comparison between the two records indicated a remarkable reduction in the species richness which was attributed to increasing water pollution.

There are many studies on fish and fisheries in Lake Burullus which could be sufficient to evaluate the recent status of the fish production and biodiversity (e.g. Libosvarsky *et al.* 1971, El-Maghraby *et al.* 1974 a, b, Hashem & Hosny 1988, Hosny & Hashem 1995), but the data in some of these studies need verification such as the exaggerated fish production (a maximum of 60,000 ton/year), as compared with the related lakes (for more details see Bishai & Khalil 1997). Some other studies carried out on the Egyptian animal biota include information about the mammals (Wassif 1995), amphibians and reptiles (Saleh 1998) and freshwater mollusks (Ibrahim *et al.* 1999) in Lake Burulus.

Lake Burullus is an important breeding area for waterbirds both at national and international scales (Meininger & Atta 1994). There is virtually no data on the function of Lake Burullus as a staging area for birds during spring and autumn migration. Considering the geographical position, the present habitat types, and a comparison with Lake Manzala, Lake Burullus is, most likely, of major importance for waterbirds (especially, herons, ducks, waders, gulls and terns). Apart from the winter surveys, a reasonably complete census of waterbirds was made in November 1981 (Bennett *et al.* 1982). Since that census was carried out after the main autumn migration period of most waterbirds between Eurasia and sub-Saharan Africa, and before the main winter influx of ducks and coot, numbers of most species observed were lower than in winter. Four winter surveys (1978/79, 1979/80, 1989/90 and 1994) were carried out for the birds of Lake Burullus (Meininger & Atta 1994 and Tinarelli 1994). In addition, an autumn survey was also carried out in 2000 (Tharwat & Hamied 2000).

There are many published and unpublished data about the socioeconomic activities in Lake Burullus site (e.g. Gazayrley 1986, Anonymous 1992 and El-Heety 1992), but some of them need updating and verification.

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Chapter 1

General Characteristics

1.1. LOCATION

Burullus Wetland is located along the Mediterranean coast in the north part of Nile Delta. It is bordered from the north by Mediterranean Sea and from south by the agricultural lands of north Nile Delta. Burullus Wetland belongs administratively to Kafr El-Sheikh Governorate. It lies in a central position between the two branches of Nile: Damietta to the east and Rosetta to the west. Its coordinates are 31° 36' N and 30° 33' E in north - west, 31° 36' N and 31° 07' E in the north – east, 31° 22' N and 30° 33' E in the south – east, 31° 22' N and 31° 07' E in the south – east. It has a total area of 460 km^2, which includes the entire area of Lake Burullus with numerous islets insides it, as well as the sand bar separating the lake from the Mediterranean Sea, with a shoreline of about 65 km. (Fig. 1.1).

1.2. GEOLOGY

1.2.1. Formation of Nile Delta

Unlike other major deltas of the world (e. g. Mississippi and Niger), the delta built by River Nile is of relatively recent geological age. A paleo-Nile started to advance across a marine embayment in the Late Pliocene, and developed especially in the Pleistocene through major sea-level changes associated with glacial periods. During low sea-level stands, large quantities of sand and mud were transported and dispersed far into the eastern Mediterranean, forming a large submarine fan (Sestini 1991).

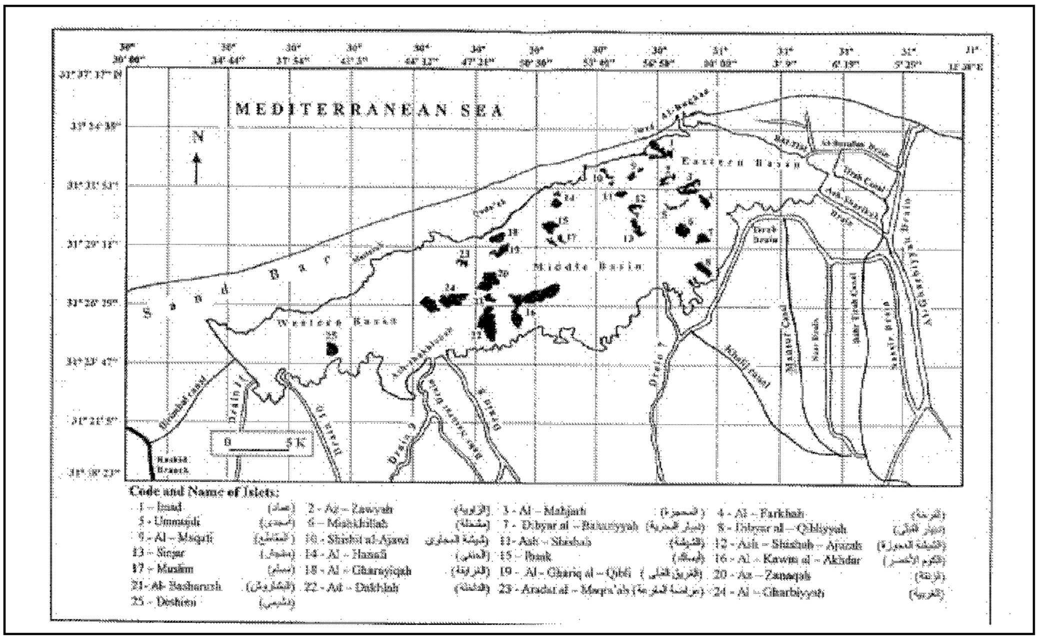

Fig. 1.1. **Sketch map of Burullus Lagoon area (prepared after the Egyptian General Survey Authority, 1992).**

In the period between 8000 to 5000 BC, when sea level began to approach its present situation, the marine transgression had reached its maximum landward extent, as far as 10-20 km inland of the present lagoons. The modern progradation started with the development of small delta lobes (Courtlier & Stanley 1987, Sestini 1989) related to several River Nile distributaries (Fig. 1.2). In the east, the lobes built by the Tanitic, Mendesian and Pelusiac and later the Damietta branches overlapped one another as they evolved. The lobes typically deflected eastward, were probably cuspate subdeltas with a notable asymmetric growth of beach ridges.

Two thousand years ago the main flow was through the western (Canopic) and the central (Sebennytic) Nile branches. The Rosetta and Damietta branches were then no more than canals. The disappearance of the older distributaries occurred mainly in the 2nd –5th centuries AD, the eastern branches (Tanitic, Pelusiac), and perhaps the Sebennytic branch, persisting until the 9th century (Tousson 1934).

Although in late Denastic – Ptloematic times much of the northern Delta was lakes and swamps (as suggested by archeological records), the Burullus and Manzala lagoons were not as extensive as today (Butzer 1976). Smaller lagoons or lakes, possibly represented as interdistributary bays, were closed-in by the longshore growth of spits from the various cuspate subdeltas. They also may have developed out of flood basins, especially during stages of large Nile floods. The lagoon expansion during the last 2000 years has been irregular,

mainly due to subsidence behind a stable beach barrier. There is a record of rapid spread of swamp and lagoons since the 5-10th centuries, in coincidence with major earthquakes (Tousson 1934, Ben Menachem 1979).

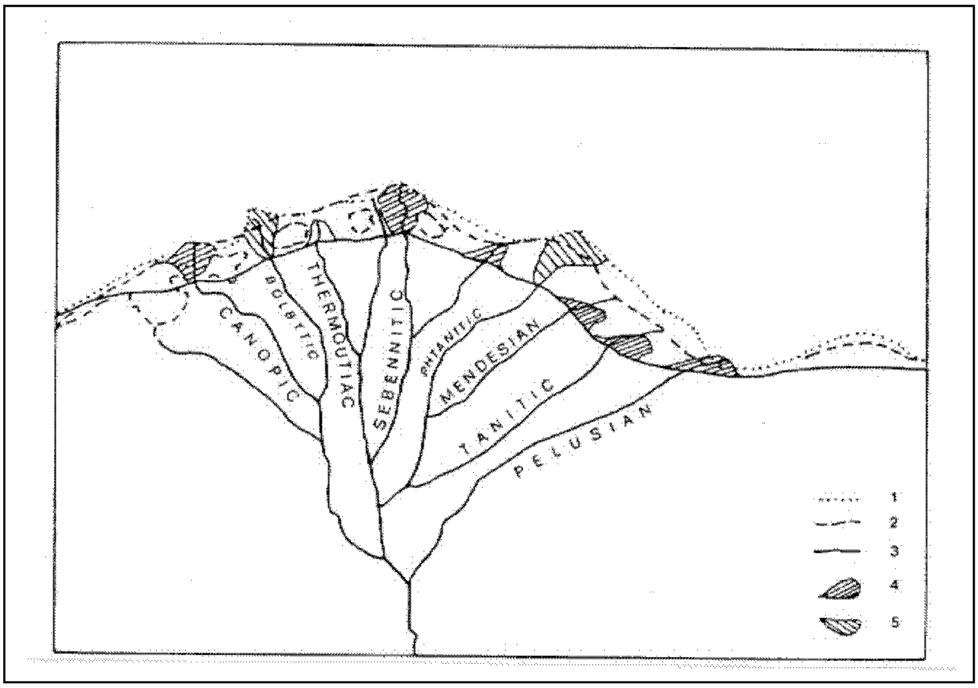

Fig. 1.2. **Nile Delta distributaries and subdeltas in pre-historic times to about 2000 BP. 1: Present coastlines, 2: Coastline 2000 BP, 3: Coastline about 7 – 8000 BP, 4: Ancient subdeltas and 5: Younger delta lobes.**

Coastal changes can be followed from maps since the early 18th century, and with more precision from topographic surveys since early 1800 (UNDP/ UNESCO 1978). Throughout the last century there was a steady advance of the Rosseta and Damietta promontories (Fig. 1.3) respectively, averaging 30 and 10 m/yr, and accretion in all the embayments towards the east. The shores east of Baltim Beach Resort as far as Gamasa, and east of the Port Said protrusion were advancing. The only exception was a slow retreat of the Burullus promontory, from west of El Burg to Baltim Beach (800 m in 100 years), a tendency probably dating back to the disappearance of the Sebennytic mouth, which was located farther north. Stretches of the Manzala barrier were also retreating.

In about 1910, an overall 25% decrease of Nile discharges, due to monsoonal reduced rainfall over eastern Africa, started the present coastal instability and headland recession. From 1910 to1965 the Rosetta promontory receded by 2.5 km (with the destruction of the first lighthouse); the Damietta promontory by about 2 km.

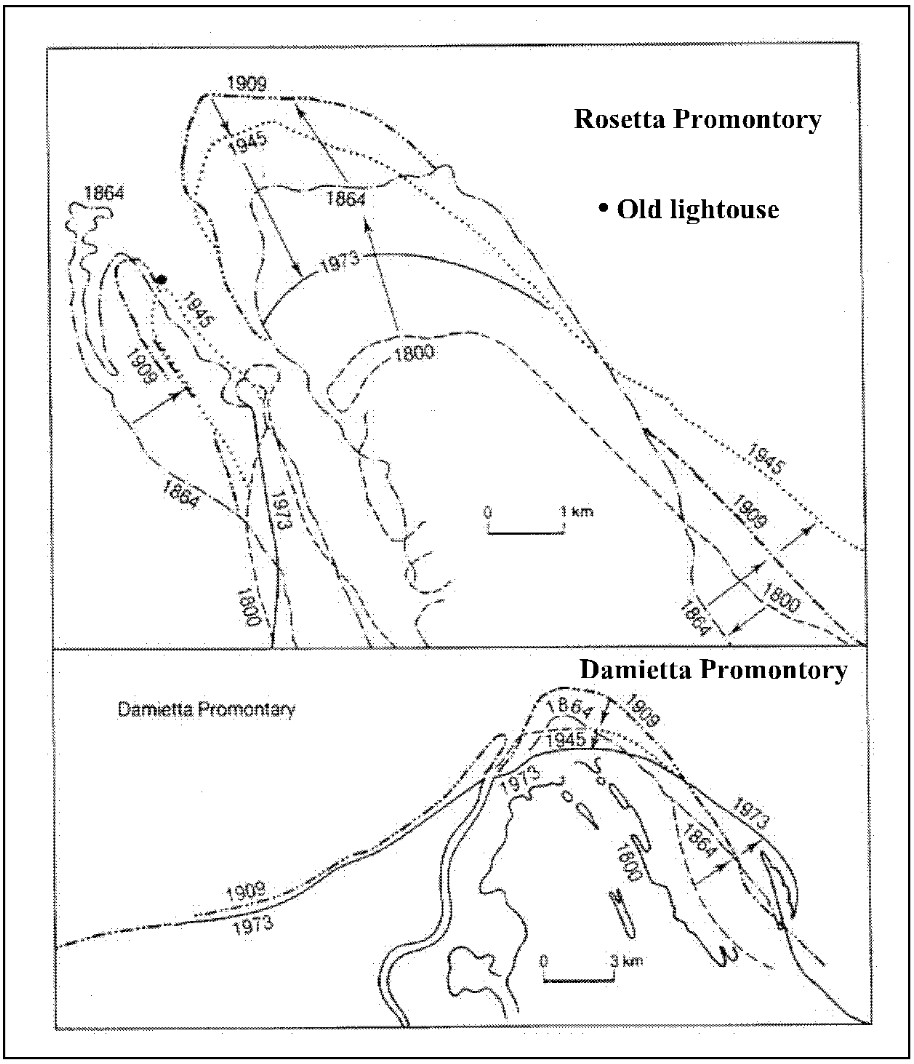

Fig. 1.3. **Coastal changes at the Rosetta and Damietta Nile mouths: 1800 – 1973 (UNDP / UNESCO 1978).**

1.2.2. Subsidence

Considerable long term subsidence of the coastal zone is indicated by the 10-80 m thick layer of post 8000 BP near shore marine, lagoonal and deltaic sediments (Fig. 1.4), with average rates of deposition as much as 5 mm yr^{-1} in the NE part of the Nile Delta, and 4 mm yr^{-1} in the central part (Coutellier & Stanley 1987). Subsidence appears to have been more intense in the lagoonal belt than near the present coast (UNDP/UNESCO 1978). Other evidence for the continued subsidence during the last 2000 years is the presence of many areas 1-3 m below sea level (Emery *et al.* 1988, Stanley 1988).

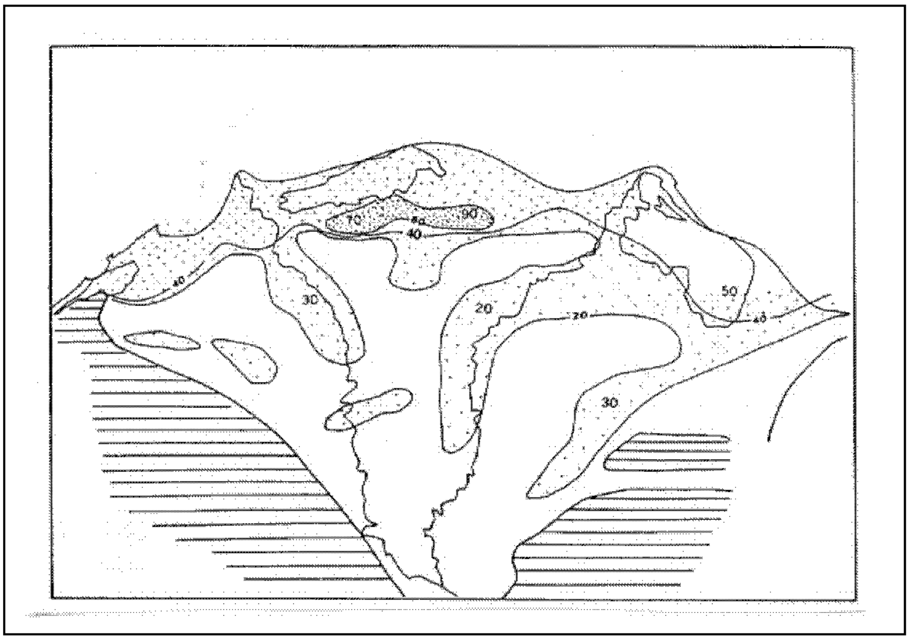

Fig. 1.4. **Thickness (in meters) of late Pleistocene-Holocene silts (post-8000 BP), as an indirect indication of geological subsidence. Horizontal ruling represents the raised Pleistocene deposits (Sestini 1989).**

According to Stanley (1988), mapping of the base of the Holocene deltaic facies, which dated at about 8000-6500 yrs BP, reveals that differential lowering of the northern delta plain is preferentially accentuated toward the northeast. The long-term subsidence rates at or near the coast, averaged for the mid to upper Holocene, range from about 0.1 to 0.25 cm yr^{-1} between Alexandria and the north-central delta margins. Rates increase markedly eastward to a maximum of about 0.5 cm yr^{-1} in the Port Said – Manzala lagoon region. This rapid lowering explains the presence of thick marine delta lobe sequences of Holocene age in cores in the northeastern delta (Hussain 1994).

1.2.3. Soils

The soils of Nile delta coastal belt are generally related to the major morphological units of alluvial plain deposition: sand dunes, coastal sand plains, Nile levees and channels (silt to fine sand), Nile flood basins composed of silt, and areas of marshes (Fig. 1.5). Modifications have been introduced by continued agricultural activity (Balba 1981).

The sandy soils of coastal littoral belt are rich in $CaCO_3$. The thickness of the "A" zone is generally 40 cm in the areas between the sand dunes. Deposited in the brackish water of lagoon- lakes and swamps, the clay soils of the fluvio-marine marshlands contain some lime but much salt and gypsum. The exchangeable Na and Mg are high, and the soils are therefore saline sodic. They

are all heavy clays, but locally loam subsoils may provide better drainage. The clay soils of former swamps are rich in organic matter.

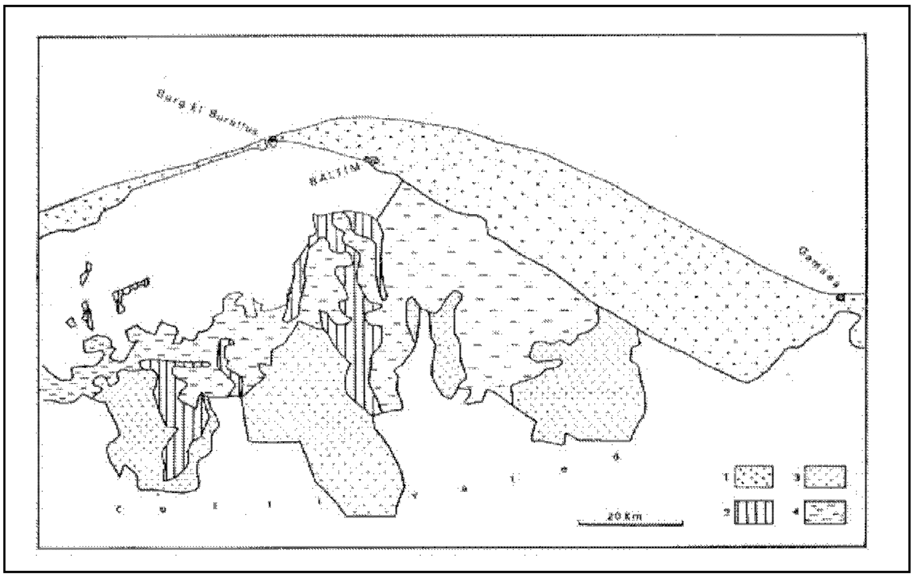

***Fig. 1.5.* Principal soil types in the north-central Nile Delta. 1: Calcareous sands, 2: Silts-fine grained sands of fluvial channels, 3: Silts (floodbasins ± salty), 4: Acid soils of former marshes: clays, loams, peats, (Sestini 1989).**

South and between the lakes, recently reclaimed areas have soils generally made of fine-textured clay and silt, normally poorly drained unless mixed with shells. The water table is shallow, about 50-100 cm from the surface. The soils are saline sodic with a high concentration of salts on the surface before reclamation. Vast areas had to be drained and irrigated with Nile water, frequently applied to improve the physical properties of the impermeable clay soils and to decrease their exchangeable sodium content (Balba 1981).

1.2.4. Coastal Processes

In Nile Delta wave energy concentration is particularly high on all north-east trending coastal stretches and promontories (Manohar 1981, Inman & Jenkins 1984). The NE- oriented stretches are attacked more by NE and N waves as a consequence of refraction, than by less frequent NE and NNE waves (Fig. 1.6). The eastward littoral drift drives the beach and the near shore sands of Nile Delta to and beyond north Sinai. Conservative estimates are that one million m^3 sand move yearly by littoral currents, which are quite strong (Fig. 1.7). In addition, large amounts of sand have been and continue to be removed from the offshore winds. Estimates of sand losses are in the order of 200,000 m^3 yr^{-1} of the Rosseta mouth, and 400,000 m^3 yr^{-1} in the Burullus – Ras El Bar coast (Manohar 1981, Smith & Abd Elkader 1988).

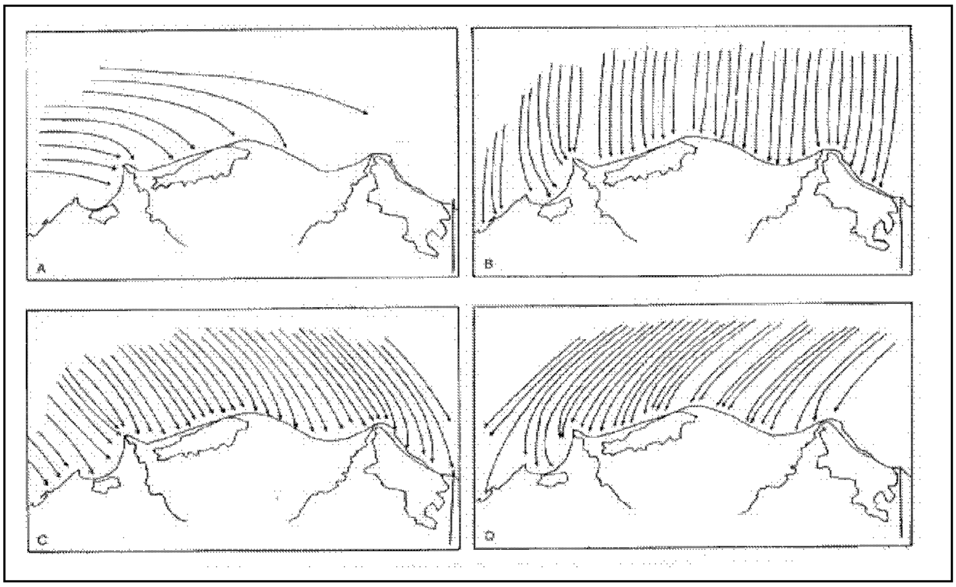

Fig. 1.6. **Main patterns of wave approach to the coast of the Nile Delta. A: Westerly waves, B: Northely waves, C: North-westerly waves, D: North – easterly waves (Tetratech 1986).**

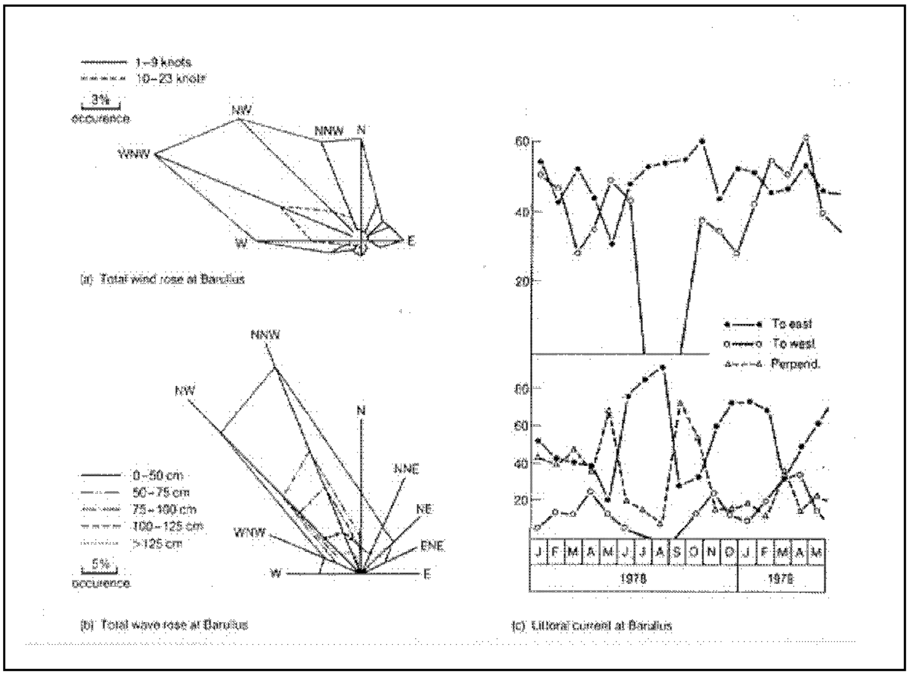

Fig. 1.7. **Waves direction and height: wind and littoral currents directions and speed at Burullus (Manohar 1981).**

Prior to the final 1964 closure of Aswan High Dam, the Nile discharged about 85-90 million tons of sediments into the sea in late summer (65% through the Rosetta, and 35% through the Damietta mouth). One- third was fine-grained sand (0.125- 0.065 mm), which was deposited in the immediate vicinity of the mouths. The other two- thirds of sediments were carried offshore and alongshore in suspension. Because of the pronounced density gradients and regional circulation, a surface plume of suspended clay and silt was carried eastward along the delta front. As shown by satellite images, such turbid plumes are still formed today, (UNDP/UNESCO 1978, Klemas & Abd Elkader 1982). At a few points on the coast (e.g., in the middle of Abu Qir Bay, between Rosetta and Burullus, east of Port Said) there may be sinks, with sands being moved off the coast to the continental shelf (Inman & Jenkins 1984).

During winter storms, the deeper fine–grained bottom sediments (silty and clay) of the Rosetta and Damietta is stirred into suspension and moved, seaward mainly to the east (Summerhayes *et al.* 1978, Frihy *et al.* 1990). The actual movement of these sands, however, is not known. Retreat is continuing on all the most exposed of the coast, and instability has been noted elsewhere (Fig. 1.8). There are a number of stretches where shoreline variability has created problems in relation to existing or planned land uses.

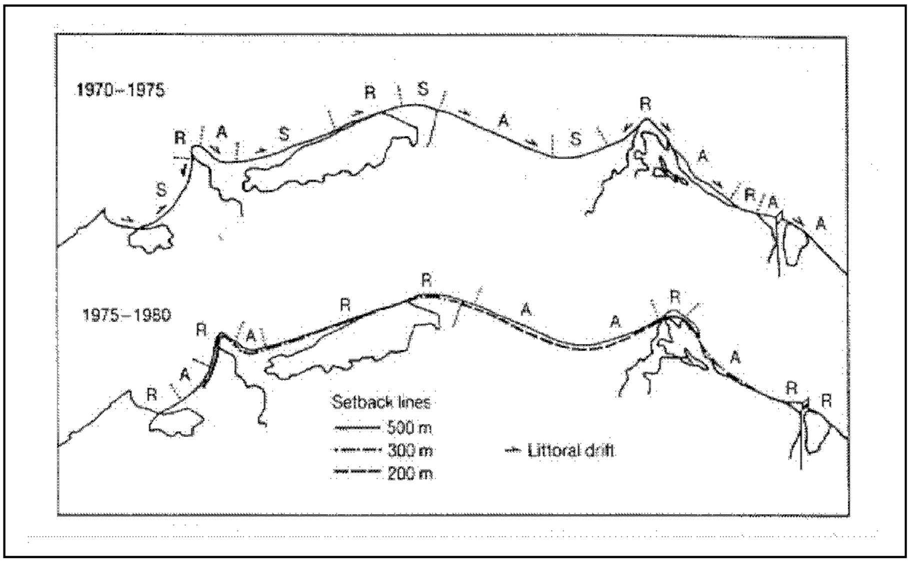

***Fig. 1.8.* The state of erosion – accretion of the Nile Delta coastline: 1970 – 1980 (UNDP/UNESCO 1978 and Tetratech 1986).**

Twenty-five years after the cessation of Nile discharge, the following conditions had been noted along the shorefront (UNDP/UNESCO 1978, Tetratech 1986, as quoted by Sestini 1991):

1- At Alexandria as the coast is directly exposed to the north western and north waves, the eastern and western harbours outer sea walls are in constant need of attention due to frequent overtopping by waves. The small beaches of the city are retreating because there is no littoral drift supply of sand. Sediment movement is complicated by the rocky capes, islands and shallow submerged rocks.
2- In the west part of Abu Qir Bay, the Mohammed Ali sea wall may be undermined by scouring. The wall which is subjected to violent action by storm waves > 2 m in height, had to be renovated in 1981-1984 (Tetratech 1986). The Idku outlet has been stabilized by jetties but flooding is common in Maadia town; a tendency of erosion to the west may be increased by the new fishing harbour. The eastern Abu Qir Bay shore is maintained by the erosion of the Rosetta promontory, the seaward sediment transport about 18 km east of Idku outlet has resulted in increased beach steeping.
3- Retreat of the Rosetta headland between 1970-1987 increased to 80-120 m yr^{-1} (Frihy 1988). Erosion of the beach barrier sands has exposed the underlying finer-grained marine sediments to wave action; the submerged delta cone is thus being eroded to 25-30 m depth or more. Intense erosion occurs especially at the river mouth and is already weakening the sea wall. This structure will eventually function as a detached breakwater, following the gradual progress of erosion at its ends; thus, it should slow down the retreat of the promontory.
4- East of the Rosetta promontory, for 30 km, shoreline tends to be stable and presumably will continue to be so for another two to three decades. East of Hanafi to 6 km west of the Burullus outlet, however, the shore is narrow and the swash zone has tended to steepen with some retreat, perhaps because of accretion at the outlet western jetty. Burg El Burullus is protected from erosion by a renovated sea wall, but at the east end of the latter, serious erosion of the sand dunes (6 m yr^{-1}) has occurred for the past 30 years. Land, however, has extended towards the lagoon, both east and west of the lake outlet (Fig. 1.9). Further east, the Burullus headland is retreating at an average of 10 m yr^{-1} with erosion of the dunes. At Baltim beach resort, where the shore had been fluctuating periodically, protection includes sand renourishment and offshore breakwaters. Active longshore and seaward sand transport prevails eastwards to Gamasa; the coast is generally stable or accreting.
5- The stretch from Gamasa drain to Ras El Bar is one of moderate longshore activity, but 7 km west of Ras El Bar retreat has occurred headland. The new Damietta harbour jetties have stimulated accretion on both sides, but have

probably modified the local wave and current regimes, with silting of the access canal. Dredging is already necessary and artificial sediment by passing may be needed.

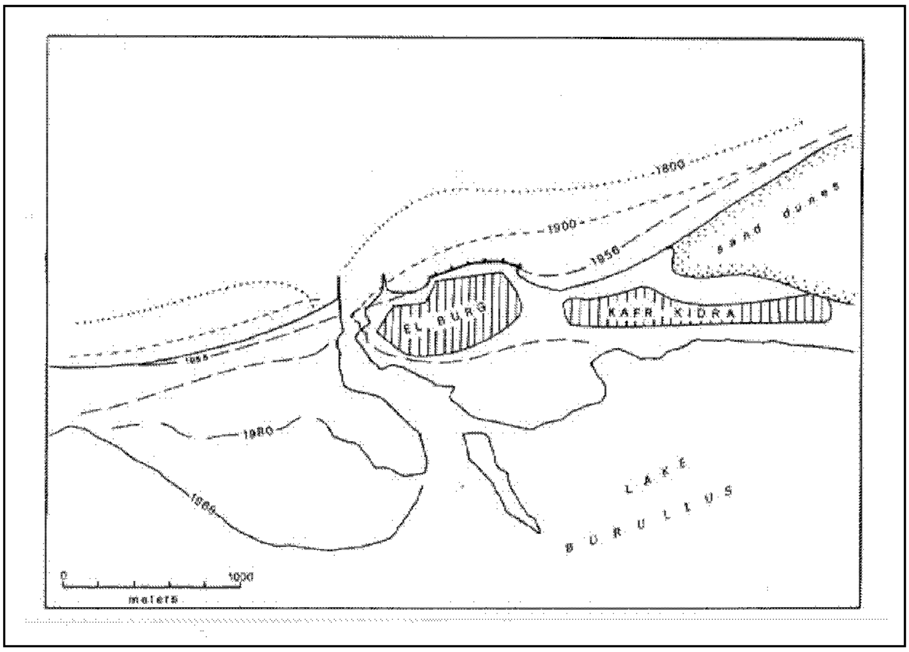

Fig. 1.9. **Topographic changes at Lake Burullus Outlet (UNDP/UNESCO 1978 and Tetratech 1986).**

6- Due to the predominant north-west wave approach, the entire Damietta promontory is under erosion and Ras El Bar protective structures have been only partially or temporarily effective. Circulation in the Nile estuary is presently entirely tidal (there's no river flow from the Farascur Dam) and dredging is required. East of Ras El Bar an earth dike extends as far as the spit (Tetratech 1986); its envisaged revetment into a stronger structure could eventually increase the erosional problems of the Nile mouth area and cause retreat at its eastern end.

7- The whole stretch from Damietta to Port Said is very unstable due to a very active longshore sand migration. The spit has been growing by 90-100 m yr^{-1} and the shoreline for 15 km eastwards is under its dynamic influence with a series of erosion-accretion patterns; the Diba embayment and hump are features that move as much as 100 m yr^{-1}; eventually they, and the spit, might encroach on the new Manzala lagoon outlet.

The section 19 km of Port Said is a unit in itself. It is a weak area except for the 4 km of Port Said western jetty, which has been accreting for over 100 years, though, at slower rate in the last decades. It is characterized by long term

retreat, the barrier between the lake and sea was reduced from 1000 to 200 m width between 1810 and 1945, and some retreat has recurred since then (UNDP/UNESCO 1978) and by frequent flooding from the sea.

1.3. GEOMORPHOLOGY AND MORPHOMETRY

1.3.1. Shape and Dimensions

The shoreline of Lake Burullus takes several forms related basically to its formation, origin and evolution. It has an oblong shape extends for a distance of 47 km along NE-SW axis (Fig. 1.1). The width of the lake from north to south varies from site to the other. The western sector has the least width which does not exceed 5 km, then it increases in the middle sector to reach an average of 11 km. As the area of the lake changed with time, its dimensions changed also (Table 1). It is obvious that the lake size had decreased from 502.7 km2 in 1984 to 410 km2 in 1997 (i.e. 18.4% reduction), the maximum length from 56 to 47 km (16.1% reduction) and the maximum width from 15 to 14 km (6.7% reduction).

Table 1.1. **Morphometric dimensions of Lake Burullus in 1984 and 1997 (after El-Bayomi 1999).**

Character	1984	1996	Reduction (%)
Area (km^2)	502.7	410.0	18.4
Circumference (km)	160.0	143.0	10.6
Maximum length (km	56.0	47.0	16.1
Maximum width (km)	15.0	14.0	6.7
Length/width ratio	3.7	3.3	10.8

1.3.1.1. Lake size

It is clear that Lake Burullus had lost about 49% of its size along 112 years from 1801 (1092 km^2) to 1913 (556.5 km^2), and about 62.5% by 1997 (410 km^2) (Table 1.2 and Fig. 1.10).

Table 1.2. **Evolution of the size of Lake Burullus during the period from 1802 to 1997.**

Character	Year						
	1801	1913	1959	1962	1972	1984	1997
Area (km^2)	1092	556.5	546.3	592.9	502.7	440	410
Reduction (%)	-	49.0	50.0	45.7	54.0	59.7	62.5

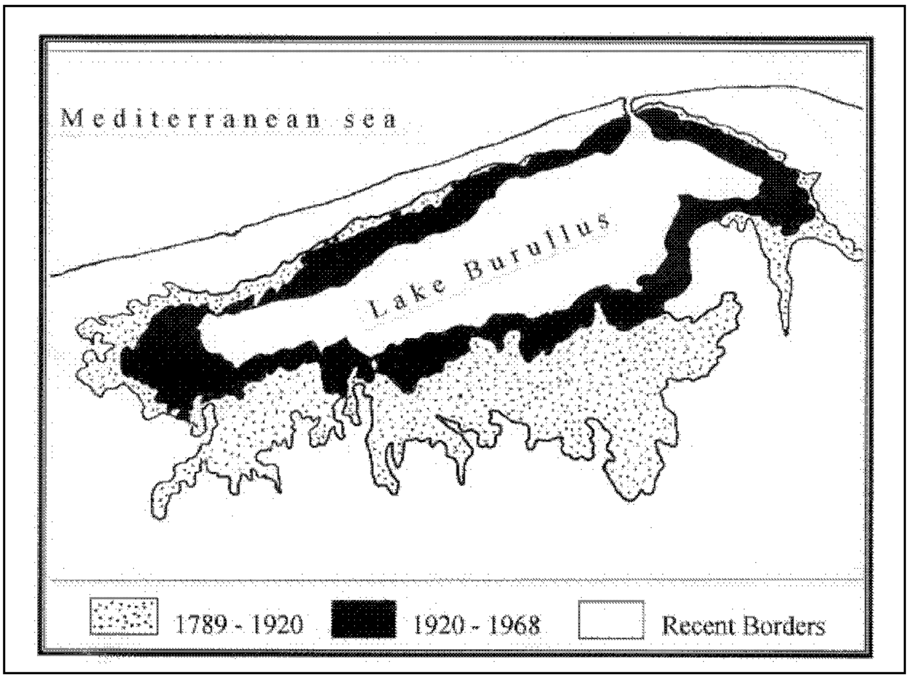

Fig. 1.10. **Size changes of Lake Burullus (1789 – 1997).**

The change in the size of the lake basin is associated with changes in the prevailing natural phenomena. The rate of these changes was assessed using the GIS and remote sensing techniques (Abdel-Rahman & Sadek 1995). As indicated in Fig. 1.11, the human impact was represented by removal of sand dunes in some parts of the marine bar between the Mediterranean sea and the lake, cultivation of some crops in the dried parts of the lake (e.g. grapes and watermelons), increase of the swamps and salt marshes particularly along the south-east and south-west parts and increase of the cultivated lands and human settlements (Table 1.3).

1.3.1.2. Lake depth

Lake Burullus is a shallow basin, its depth varies between 40 cm near the shores and 200 cm near the sea outlet (Boughaz El-Burullus). The remote sensing studies indicated that the deepest parts was in the middle sector of the lake where the depth reached 200 cm, and also the southern parts of the western sector (west of Doshimi islet). The eastern sector is the shallowest where the depth does not exceed 20 cm near the shore, but increases westwards until it reaches about 70 cm (Fig. 1.12).

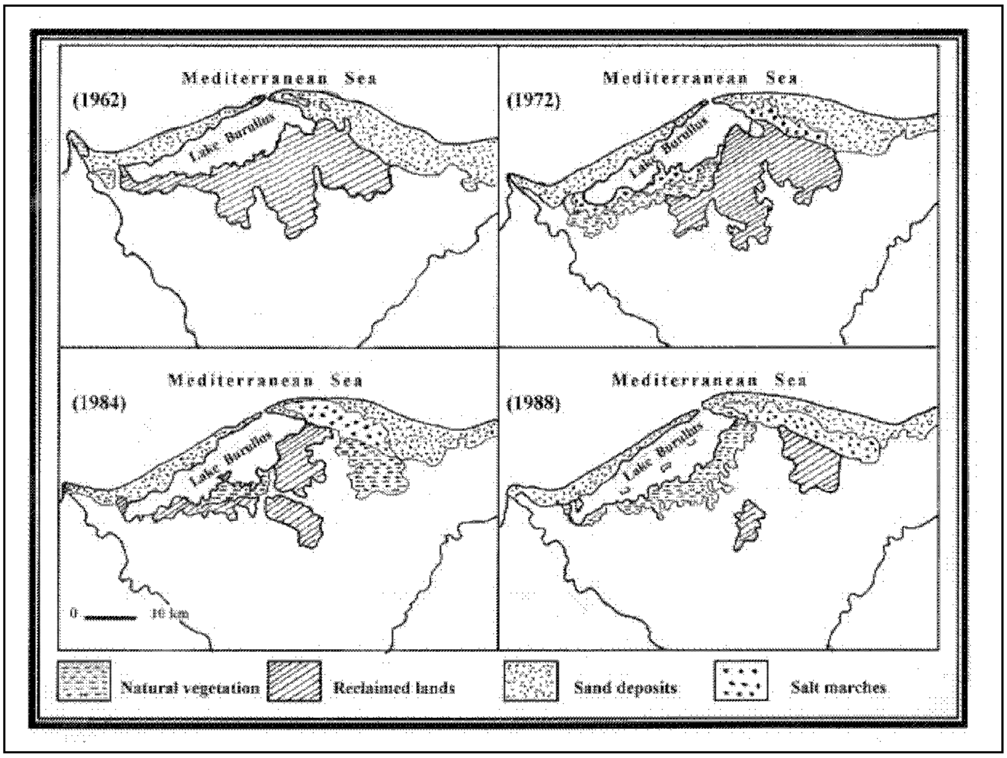

Fig. 1.11. **Morphological change in Lake Burullus (After Abdel Rahman & Sadek 1995).**

Table 1.3. **Changes in the water body, natural and anthropogenic phenomena in Burullus Wetland (Abdel-Rahman & Sadek 1995, El-Bayomi 1999).**

Character (km^2)	**Year**			
	1962	**1972**	**1984**	**1997**
Water body	592.9	502.7	440	410
Swamps (under reclamation)	210.7	215.5	315.4	388.5
Sand deposits	866.5	660.8	569.7	266.9
Natural vegetation (under reclamation)	101.6	134.6	190.1	388.6
Reclaimed areas and settlements	-	-	448.1	623.8

Due to the continuous morphological and water budget changes, particularly after constructing many irrigation and drainage projects, and silting of Boughaz El-Burullus, the depth of the lake changes from time to time. The changes that happened during the period from 1984 to 1997 was studied using GIS system. The hypsographic analysis (Table 1.4) indicated that the contour line zero (i.e. the shore line of the lake) is about 143.5 km. The area between the shore line

and 75 cm depth approximates 58% of the total area of the lake (236.6 km^2 out of 410 km^2). Thus, it seems that the lake lives its senility stage particularly with the continuation of drying and silting up processes which lead to the increase of shallow areas; the areas deeper than 130 cm have already decreased to about 20.6 km^2 (5% of the lake size).

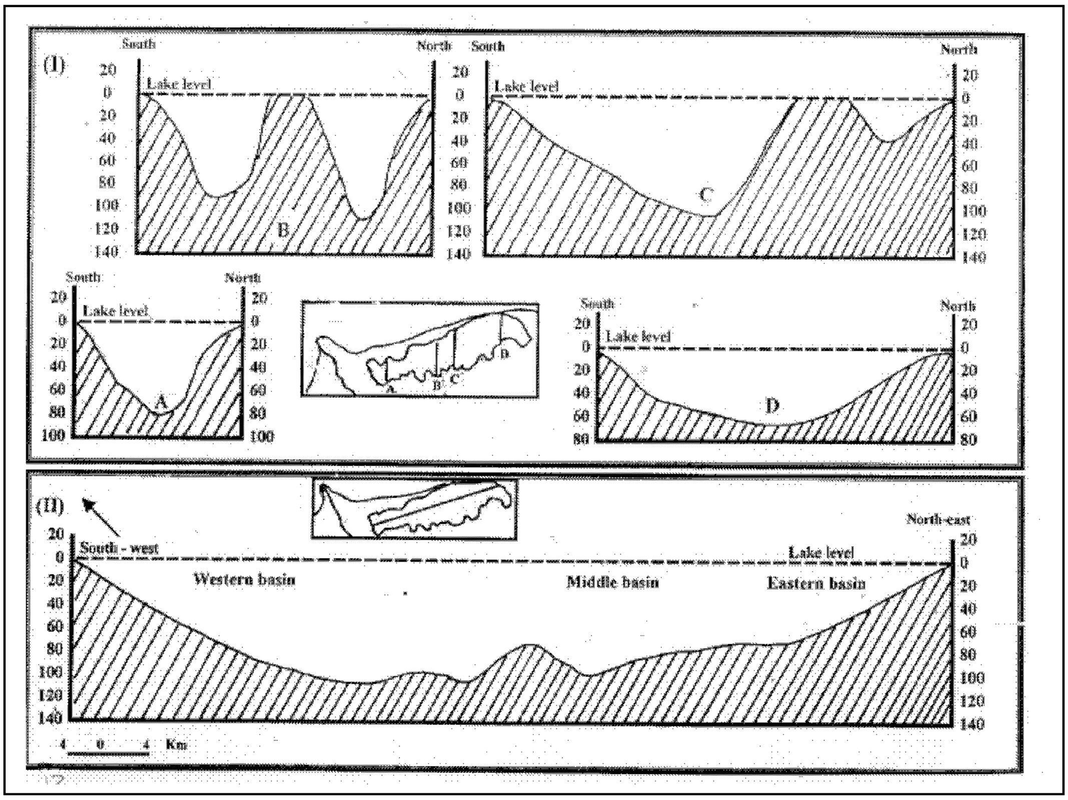

Fig. 1.12. **Transverse (I) and longitudinal sections (II) in the main basin of Lake Burullus indicate the variation in water depth (redrawn from El-Bayoumi 1999).**

Table 1.4. **Hypsographic analysis of Lake Burullus basin (after El-Bayomi 1999).**

Water depth (cm)	**Contour line (km)**	**Size between two contour lines (km^2)**	**%**
Zero	143.5	410.0	-
0 – 50	130.0	122.7	30
50 – 75	95.0	113.9	28
75 – 100	65.0	89.0	22
100 – 130	55.0	63.8	12
> 130	45.0	00.0	5

1.3.2. Morphometric Units Inside the Lake Basin

The main basin of Lake Burullus is classified into three sectors: eastern, middle and western, each one has some sort of homogeneity in the geomorphological, hydrological and biological characteristics. The islets scattered in the lake form physical isolations between these sectors (Fig. 1.11). The dimensions of these sectors and the distribution of islets inside them are presented in Table 1.5.

***Table 1.5.* Dimensions of the three sectors of Lake Burullus and the distribution of islets inside them (after El-Bayomi 1999).**

Sector	Area		Islets		Density of islets
	km^2	%	No.	%	($islet/km^2$)
Eastern	117.6	28.7	11	36.7	0.09
Middle	189.0	46.1	15	50.0	0.08
Western	103.4	25.2	4	13.3	0.04
Total	**410.0**	**100**	**30**	**100**	**0.07**

1.3.2.1. The eastern sector

This sector lies at the eastern part of the lake and separated from the middle one by the islets of Mesallam, Absak, Kom Absak, and from the south by Dinar Al-Baharyya, Singar and Baker islets. The sea outlet (i.e. Boughaz El-Burullus) lies at a midway north of this sector. The area of the eastern sector is about 117.6 km^2 (28.7% of the total area of the main basin of the lake). Its maximum width is about 14 km and comprises 11 islets (36.7% of the total islets). It is the shallowest sector with depths that vary between 40 and 75 cm, but the area near the sea outlet is among the deepest areas in the lake (it approximates 200 cm). The water in this sector has special characteristics due to the saline water that flows from the sea, and the blowing of the north-western winds.

1.3.2.2. The middle sector

It lies between the eastern and western sectors with an area of 189 km^2 (46.1% of the main basin). It comprises 15 islets (half of the total islets in the main basin). Some of these islets are the biggest in the lake: e.g. Al-Kawm Al-Akhdar (2.8 km^2) and El-Dakhala (1.0 km^2). The depth of the areas near its northern shore does not exceed 40 cm, but increases towards the center until reach 130 cm, and decreases again towards the southern shore due to high sedimentation rates from the drains that pour in this region (Fig. 1.12). The

water in this sector has a medium salinity in relation to the eastern (relatively high salinity) and western (relatively low salinity) sectors.

1.3.2.3. The western sector

Its area is approximately 103.4 km^2 (25.2% of the area of the main basin). It has the shortest width (about 4 km) and the lowest number of islets (4 = 13.3 % of the total number of islets). It is separated from the middle sector by the islets of Al-Fakaa, Doshimi, Abu-Amer and bab Al-Askala.. The depth of this sector increases westwards, then decreases gradually towards the western shore of the lake.

1.3.3. Geomorphological Features of the Marine Bar

The marine bar (i.e. sand bar) of Lake Burullus is the zone that separates the Mediterranean coast in the north from the lake shore in the south. It extends between latitudes 31° 23` 26`` to 31° 34` 48`` N and longitudes 31° 2` 48`` to 31° 7` 30`` E and covers an area of about 165 km^2 (Fig. 1.1). Although the surface of this bar is relatively flat, but it has different geomorphological features that had been formed upon it as a result of the evolution and development of the geomorphological processes. Some of these features were related to the sedimentation process such as sand flats, sand dunes and sand hillocks; and some others were due to change of sea level like salt marshes and tidal flats.

1.3.3.1. Sand flats

The surface of the marine bar is covered by sand flats particularly along the north western margins of the lake. These flats have a few undulation and sometimes form what is called "sand ripples". The winds are the main effective factor in the formation and direction of the sand ripples, their axes extend from north-east to south-west (i.e. direction of the prevailing winds in this region). The main types and characteristics of sand ripples are (after El-Bayomi 1999):

1- Regular sand ripples. Relatively straight with small slip faces, strongly sloped and perpendicular with the wind direction.
2- Irregular sand ripples. Their irregularity is due to changes in the direction and velocity of wind. They predominate in the relatively elevated and arid area far from the shoreline.

1.3.3.2. Sand dunes

Sand dunes in the marine bar of Lake Burullus represent the principal geomorphological feature affected by the sedimentation processes. Natural factors helped in presence of this geomorphological feature where a close relation was found between the locations of the sand dunes and the ancient Nile Deltiac branches (Fig. 1.13). The coastal sand dune formations are desertic sands: from the western desert where the predominant western winds helped in

their formation after mixing with the Nile deposits of the ancient Nile Deltiac branches and the marine deposits carried by the marine currents, particularly in the north eastern part of the marine bar. In general, the sand dunes along this bar could be classified into:

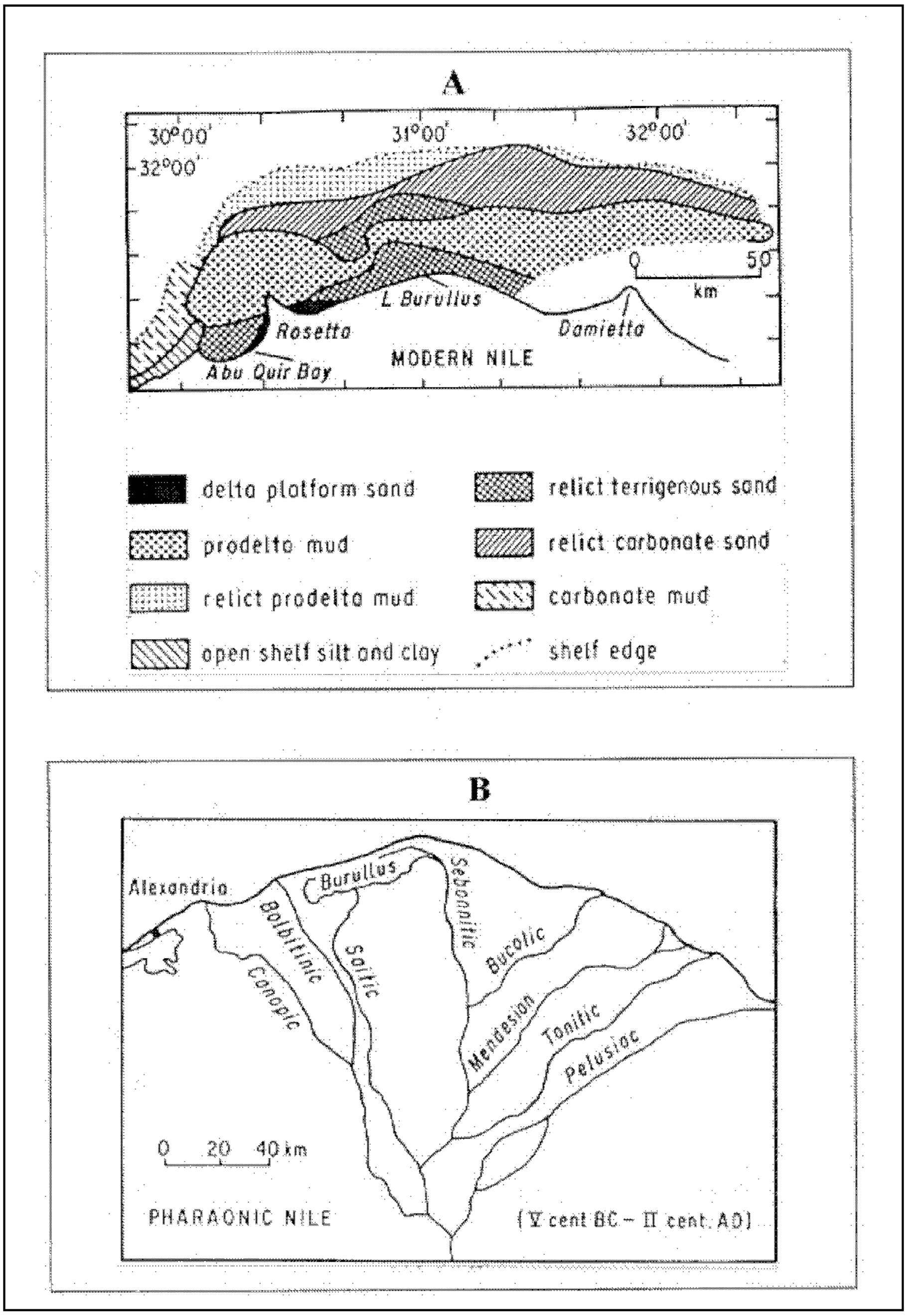

***Fig. 1.13.* Maps showing the continental shelf of the Nile Delta (modified from Summerhayes *et al.* 1978). A: simplified faces distribution on the Nile Delta shelf, B: ancient Nile River distribution.**

1- Barchan embryonic sand dunes: They represent the first stage of dune formation, and usually take the crescent shape with heights that do not exceed 3 meters. They predominate in area between Burg El-Burullus and Baltim.
2- Longitudinal sand dunes: They were formed as a result of helicoidal air currents and strong winds that blow frequently in one direction whereof lead to change the crescent shapes of the dunes into longitudinal ones. Their heights approach 4 to 5 m with mean length of 500 m, and mean width of 50 m. This type of dunes is common in the eastern parts of the marine bar. Their axes are parallel to the direction of the prevailing winds in this region.
3- Complex dunes: This type is dominant in Baltim, Sheikh Mubarak and some other zones in the marine bar. They have several apices and seem to be broad and irregular. Their height approach 13 m above sea level and their axes deviate from the north apparently related to the direction of the prevailing winds.

1.3.3.3. Sand hillocks

Sand hillocks are embryonic dunes with heights that range between a few centimeters and a few meters. They have domal or longitudinal shapes. Their windward sides are covered by some herbs and shrubs (e.g. *Tamarix nilotica*) that help in the fixation of these hillocks. The factors that lead to the formation of these hillocks are the friable sands of different sizes, sparsity of vegetation, relative flatness of the soil surface, absence of the physiographic barriers and the blowing of winds with different velocities and directions. El-Bayomi (1999) has carried out some morphometric measurements on some hillocks distributed in the area between Burg El-Burullus and Baltim in the eastern part of the marine bar, and Arab El-Hefny and Kom Meshal in its western part. It is shown in Table 1.6 that the hillocks length ranges between 1.5 and 2.9 m, the width between 0.5 and 1.8 and the height between 0.5 and 0.9 m.

Table 1.6. **Morphometric measurements of the dimensions of some hillocks in the marine bar of Lake Burullus.**

Dimension		Range	Mean ± SD
Length	m	1.5 - 2.9	2.6 ± 0.45
Width	m	0.5 - 1.8	1.3 ± 0.46
Height	m	0.5 - 0.9	0.6 ± 0.16
Windward slope degree	o	1.5 - 5.0	2.8 ± 1.03
Leeward slope degree	o	1.6 – 7.0	4.3 ± 1.85

It is well known that the plant species play an important role in determining the size and consistency of the hillocks (i.e. phytogenetic hillocks) to the extent of establishment of a close positive relationship between the height of hillocks and the height of the plants that cover them. *Zygophyllum album*, *Arthrocenmum strobilaceum* and *Tamarix nilotica* are among the species of

close association with the hillock formation in this region (i.e. sand binding plants). When the hillocks approach each other, they merge together and form large dunes covered by dense vegetation.

1.3.3.4. Salt marshes

Coastal salt marshes are lowlands near the coasts, covered with water during the tide, have increasing salinity particularly with the increase of evaporation rate, and covered with salt tolerant plants of high capacities for trapping and fixing soil deposits. They extend along the marine bar of Lake Burullus with an area that approximates 40% of the total area of the bar (6% only found in the eastern part, and 34% in the western part due to the relative low level of its surface). Their clay deposits vary between 60 and 80%, which may indicate that the origin of these marshes were associated with the primary stages of the initiation of the whole area. With the flowing of the ancient Nile Deltiac branches, and with the help of wind and marine currents, the sand deposits spread over the area.

Tidal action is considered among the principal factors responsible for the formation and development of salt marshes along the marine bar of Lake Burullus. With the extension of water during tide and retreating during ebb-tide, and with the gentle sloping of the shore, tidal waters extend to cover vast areas that increase with the happening of storm waves. Natural vegetation plays an important role in the development and evolution of salt marshes as it leads to increase evaporation rate and salinity. Moreover, the heavy growth of salt tolerant plants trap the deposits and help in leveling up the beds of the marshes.

1.3.3.5. Tidal flats

These flats extend along the shore between Burg El-Burullus and Baltim in the eastern part of the bar. They are usually submerged by sea water during the tide, while the water retreats during the ebb-tide. The surface of these flats consists of materials with homogeneous sizes and seems to be devoid of plants. With movement of waves over these flats, current wave ripple marks appear, their axes extend parallel to the shore with depths that vary between 4 and 6 cm, and widths between 15 and 20 cm. This phenomenon is a temporary one. The sources of tidal flats are the friable sands transported by the north-western winds, the deposits produced as a result of shore erosion by the effect of waves, and the deposits transported by the tidal and coastal currents.

1.3.3.6. Sea outlet

The outlet that connects the Mediterranean Sea with Lake Burullus is called Boughaz El-Burullus. From the original viewpoint, it is a natural water course. Its length approximates 250 m, the width at the narrowest point is about 50 m, and the water depth varies between 50 cm and more than 200 cm. This

outlet crosses the marine bar at the narrowest point, where the soil surface is flat and devoid from sand dunes. The main factors that affect its morphology are:

1- The shape of the outlet as a protrusion inside the sea, where the attack of waves become more strong than the other parts of the bar. This often leads to deepen the area around the outlet.
2- The movement of water into and from the lake during the tides leads to widen the outlet (Table 1.7).

Table 1.7. **Amount of the water exchanged between Lake Burullus and Mediterranean Sea. Coastal Protection Agency 1996 (as quoted by El-Bayomi 1999). Maximum current velocity is 54 m sec^{-1}., while mean current velocity is 26 m sec^{-1}.**

Character	**m^3 sec^{-1}**	**10^6 m^3 day^{-1}**
Maximum discharge into Sea	98	8.47
Maximum flow from Sea	95	8.21
Mean discharge into Sea	45	3.89
Mean flow from Sea	40	3.46

3- The shore currents that move from the sea into the lake. With the weakness of these currents, displacement or pushing effects of the waves that come towards the lake decrease which leads to silting up and closing of the outlet.
4- The waves that approach parallel to the shoreline move sediments from the sea bottom.
5- Human activities are among the main factors that affect the morphology of the outlet. Man changes the shape and dimension of Boughaz El-Burullus by constructing sand and wave barriers, artificial digging and deepening.

1.3.4. Morphology of the Lake Islets

Many islets with different sizes are distributed in Lake Burullus (Fig. 1.1). Due to the continuing of the effects of the geomorphological processes (e.g. sedimentation, erosion and water flooding), the number, size, dimensions and locations of these islets change from time to time. They move from their locations or merge together when become close to each other.

The number of islets in Lake Burullus has changed along the years. This was associated with differences in the physical factors that affected the whole region such as: 1- change of the lake size, 2-change in hydraulic conditions of the water courses that pour their loads into the lake, 3- full controlling of the irrigation and drainage system, after the building of High Dam, and 4- merging of some islets with the lake shores, particularly in the southern part, due to the drying of some parts of the lake for the agricultural purposes (Table 1.8).

Table 1.8. **Change in the number of islets in Lake Burullus during the period from 1789 to 1997 (after El-Bayomi 1999).**

Sector	1789	1920	1952	1972	1984	1997
Eastern	52	38	34	14	15	1
Middle	81	22	20	17	17	15
Western	25	20	18	17	13	4
Total	**158**	**80**	**72**	**48**	**45**	**30**

The size of islets, as their numbers, has changed with time. The size of some islets has increased due to merging with the nearby islets as a result of increasing rates of sedimentation (Table 1.9). The heavy growth of reed and sedge plants (e.g. *Phragmites ausralis* and *Typha domingensis*) facilitates the merging of these nearby islets. Due to continuing of geomorphological processes and photometric changes, the number and size of Lake Burullus islets will be changed. A new islet appeared in the north of the eastern sector near the sea outlet. Doshimi islet in the western sector approaches to merge with the southern shore, while Shishit Al-Aggari and Makatee Al-Aggari islets in the eastern sector will merge together in the near future.

Table 1.9. **Change in size of islets in Lake Burullus during the period from 1789 to 1997. E, M and W are the eastern, middle and western sectors of the lake, T: total.**

Size	< 0.5 km^2				0.5 – 1.0 km^2				> 1 km^2				Total
Sector / Year	E	M	W	T	E	M	W	T	E	M	W	T	
1789	42	66	15	123	5	8	10	23	5	7	-	12	158
1920	26	11	8	46	7	6	12	25	5	5	-	10	80
1925	23	9	9	41	6	5	8	19	5	6	1	12	72
1972	3	7	14	24	6	5	2	13	5	5	1	11	48
1984	4	5	9	18	5	4	2	11	6	8	2	16	45
1997	2	2	1	5	3	2	2	7	6	11	1	18	30

Islets of Lake Burullus could be classified according to their shapes into different groups : longitudinal (e.g. Dibar), circular or oval (e.g. El-Zanka), triangular (e.g. Doshimi), arc (e.g. Shishet Al-Agoza), curved (e.g. El-Zoaya) and irregular (El-Maghara and Absak). Many islets have obvious longitudinal extensions parallel with the directions of the prevailing western winds, their axes usually extend from north to south, and occasionally from north to east. Their surface levels approach 3 meters above water level of the lake, thus they are called hills or piles, where some remains of settlement centers related to Romanian era are still found over some of them (e.g. Singar islet in the eastern sector). The surface levels of some other islets (e.g. El-Zanka, Farash El-Toob

and El-Dakhla in the middle sector) approach the water level of the lake, sometimes the water submerged them particularly during the increase of water flow from the sea and drains.

In general the remote sensing study of Guirguis *et al.* (1996) on Lake Burullus indicated that the erosion and accretion were effective factors at different times. Erosion occurred during 1983 and accretion during 1985 (Fig. 1.14). Erosion is still continuing although protection procedures are in effect on the eastern side of the sea outlet during the last few years. Accretion is found only at the western part of the sea outlet. Lake area decreased during the period of study (1983 to 1991) at an average rate of 8.6 km^2 yr^{-1}. The rate of increase of reclaimed areas by drying from the lake body was higher during the period 1983 to 1985 (27.5 km^2 yr^{-1}) than during 1985 to 1991 (2. 33 km^2 yr^{-1}).

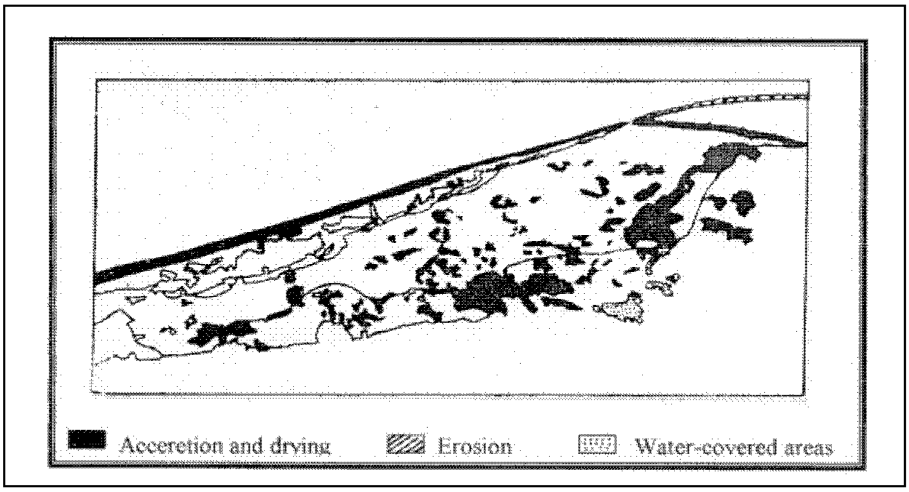

Fig. 1.14. **Map of Lake Burullus depicting major change during 1983 – 1991 (after Guirguis *et al.* 1996).**

1.4. CLIMATOLOGY

According to the map of world distribution of arid regions (UNESCO 1977), the northern part of Nile Delta belongs to the Mediterranean arid region. The climatic conditions are warm summer (20 to 30 °C) and mild winter (10 to 20 °C). The aridity index (P/PET: where P is the annual precipitation and PET is the potential evapo-transpiration) ranges between 0.03 and 0.2 at the north Delta (arid region), and less than 0.03 at the south (hyperarid region). Long-term climatic averages of three meteorological stations distributed within Burullus Wetland were used to draw their climatic diagrams (Fig. 1.15).

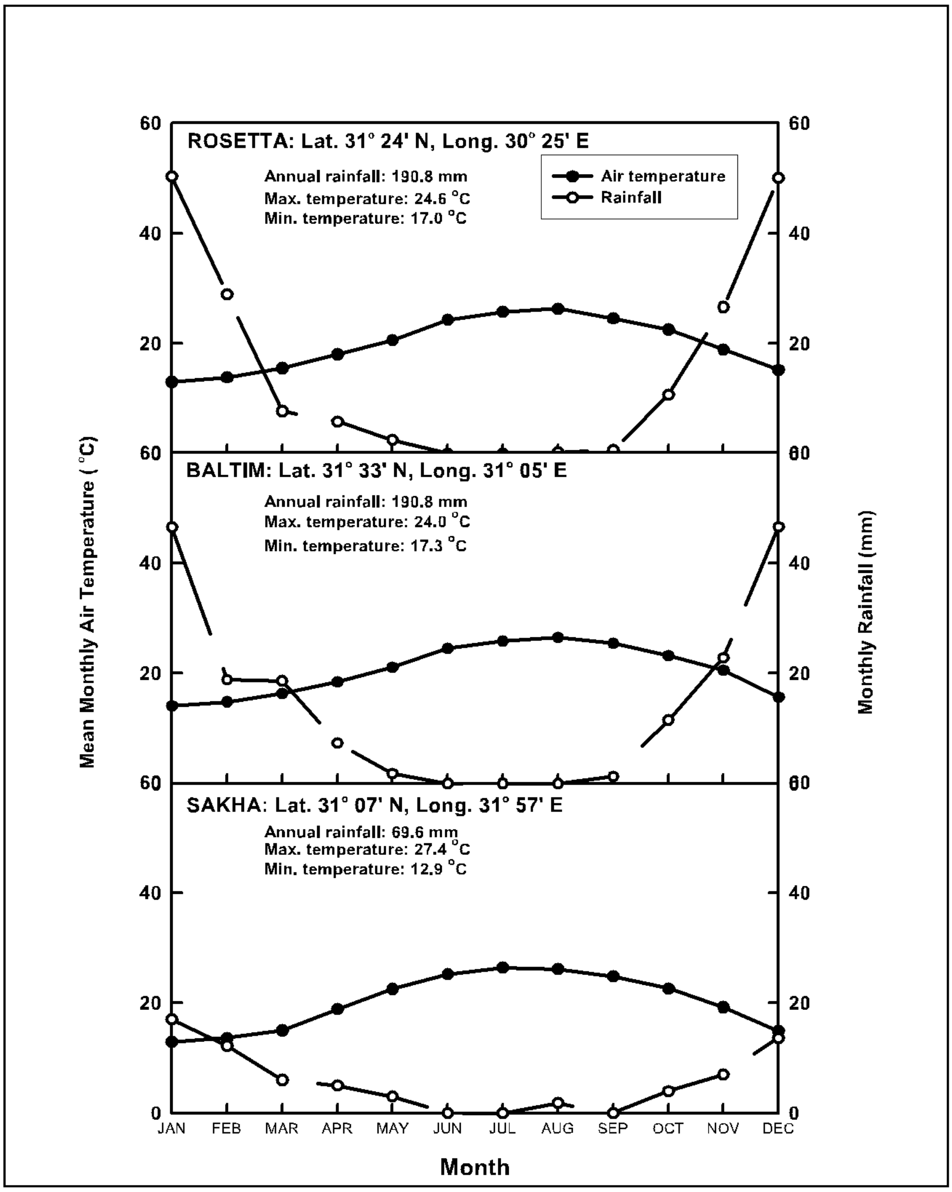

Fig. 1.15. **Climatic diagrams of Rosetta, Baltim and Sakha metereological stations**

In general, January is the coldest month, while July and August are the hottest. The annual mean maximum temperature varies between 24°C at Baltim and 27.4 °C at Sakha, and that of minimum varies between 12.9 °C at Sakha and 17.3 °C at Baltim (Table 1.10). The annual mean of wind speed varies between 2.9 knot at Sakha and 6.6 knot at Baltim. The annual means of relative humidity, evaporation and sky cover exhibit narrow ranges of variation

Table 1.10. **Long-term averages (≥ 20 years) of the climatic records of Burullus Wetland (after the Climatic Normals for the Arab Republic of Egypt up to 1975: Anonymous 1980). *: total annual rainfall in mm.**

Month	Air temperature (°C)			RH	RF	EV (mm	WS	SC
	Max.	Min.	Mean	(%)	(mm $month^{-1}$)	day^{-1})	(knot)	(oktas)
a- Baltim station: Lat. 31° 33' N, Long. 31° 05' E								
January	17.4	11.2	14.1	72	46.5	3.3	7.0	3.3
February	17.9	11.6	14.8	68	18.8	3.9	6.8	2.8
March	19.9	13.1	16.3	65	18.6	4.8	8.1	2.8
April	22.5	14.9	18.4	67	7.3	5.2	7.8	2.4
May	25.5	17.7	21.1	67	1.8	5.2	6.8	1.5
June	28.5	21.2	24.5	69	Tr.	5.6	7.1	0.8
July	29.3	22.9	25.8	73	Tr.	5.4	7.6	0.9
August	29.7	23.6	26.5	72	0.0	5.2	7.0	1.0
September	28.0	22.2	25.4	70	1.3	5.0	5.5	0.9
October	26.8	20.0	23.2	68	11.5	4.5	4.5	1.6
November	23.3	16.9	20.6	70	22.8	3.9	5.1	2.4
December	19.0	12.8	15.7	71	46.6	3.5	6.5	3.1
Mean	24.0	17.3	20.5	69	175.2*	4.6	6.6	2.0
b- Rosetta station: Lat. 31° 24' N, Long. 30° 25' E								
January	18.1	10.8	13.0	69	50.3	3.3	5.4	3.4
February	18.7	10.8	13.8	71	28.9	3.7	5.5	2.9
March	20.4	12.3	15.5	65	7.7	4.1	6.4	2.7
April	23.0	14.4	18.0	66	5.8	4.4	5.9	2.6
May	26.0	17.4	20.6	65	2.5	4.6	5.0	1.9
June	28.4	20.0	24.3	66	Tr.	4.8	5.2	1.0
July	29.6	23.0	25.7	70	0.0	4.8	5.5	1.1
August	30.4	23.4	26.3	71	0.2	4.8	4.5	1.2
September	29.5	22.8	24.5	70	0.6	4.8	4.1	1.4
October	27.5	19.8	22.5	72	10.7	3.6	3.7	1.9
November	23.8	16.4	18.9	72	26.6	3.8	4.0	2.8
December	20.1	12.5	15.2	70	50.0	3.3	5.3	3.2
Mean	24.6	17.0	19.8	69	190.8*	4.2	5.0	2.2
Sakha station: Lat. 31° 07' N, Long. 31° 57' E								
January	19.4	6.4	12.9	74	17.0	2.2	2.8	3.1
February	20.6	6.5	13.6	72	12.2	2.7	3.1	3.0
March	22.0	8.0	15.0	69	6.0	3.5	3.3	2.5
April	27.0	10.8	18.9	64	5.0	5.0	3.3	2.1
May	30.9	14.1	22.5	60	3.0	6.5	3.2	1.9
June	33.1	17.2	25.2	62	Tr.	6.7	3.1	1.2
July	33.7	19.1	26.4	66	0.0	5.7	2.8	1.4
August	33.6	18.6	26.1	69	1.8	5.0	2.6	1.4
September	31.9	17.7	24.8	70	Tr.	4.8	2.5	1.6
October	29.7	15.5	22.6	71	4.0	3.8	2.5	2.2
November	25.7	12.6	19.2	73	7.0	2.8	2.7	2.8
December	21.4	8.4	14.9	75	13.6	2.1	3.0	3.1
Mean	27.4	12.9	20.2	69	69.6*	4.2	2.9	2.2

among stations. The total annual rainfall has a maximum value at Rosetta (190.8 mm yr^{-1}) and a minimum at Sakha (69.6 mm yr^{-1}). The isohytes of the mean annual rainfall in Egypt (Griffiths 1972) indicates that Lake Burullus is between the isohyte 200 mm at its northern border and the isohyte 150 mm at its south (Fig.1.16). In general, the distribution of the mean annual rainfall in this region shows a maximum close to the Mediterranean coast and then decreases rapidly toward the south. More than 80% of the rain falls during winter, and only less than 10% falls during spring.

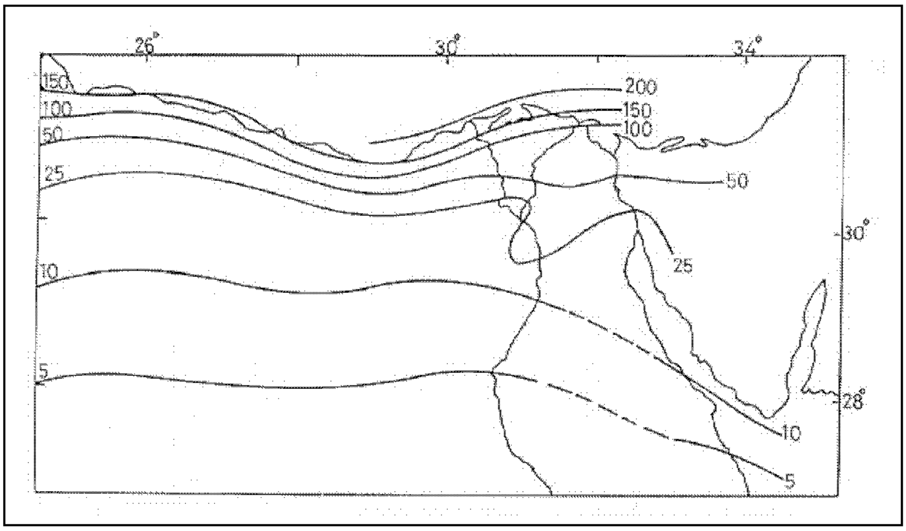

Fig. 1.16. **The isohytes of the mean annual rainfall in Egypt (after Griffiths 1972).**

The pluviothermic index of Emberger (Emberger 1955) has a decreasing trend with a maximum at Rosetta (Q = 21.7), followed by Baltim (Q = 21.5) and Sakha (Q = 11.3) stations.

1.5. HYDROLOGY

1.5.1. Hydrogeology

The Quaternary alluvial deposits in the Nile Delta form the main ground water aquifer (Nile Delta aquifer). The deposits consist of sand and gravel with a relatively high hydraulic conductivity. The Quaternary deposits are underlain by late Tertiary clays, which act as the main aqueduct. In the Nile floodplain, a Holocene clay layer that creates semi-confined conditions covers the aquifer. The ground water in the Quaternary aquifer is not a resource in itself as it is in hydraulic contact with the surface water system (i.e. River Nile, drainage and irrigation canals). Groundwater that is pumped from the aquifer is continuously

replenished by surface water or intruding seawater. The aquifer is in fact a large storage reservoir supplied by the Nile water through the net of irrigation system.

The average thickness of the clay cap is less than 20 m. The thickness increases northwards where it reaches about 70 m along Mediterranean Sea. The clay cap is followed by silty soft clay or sandy clay layers. The clay cap is an isotropic with permeability in the vertical direction much less than in the horizontal direction. Field measurements and laboratory experiments showed high variations in the values of vertical permeability. A value of 2.5 mm day^{-1} has been adopted estimate of the vertical upward flow through the clay cap. This value is quite low and seems to be very conservative if it is considered for the whole leaky aquifer (El-Shinnawy 2002).

The Quaternary aquifer is highly productive and generally contains good quality water (TDS less than 1000 ppm). In the northern part of Nile Delta, the salinity increases to more 10,000 ppm over a relatively short distance due to seawater intrusion.

1.5.2. Groundwater Movement

The catchment area of Burullus Wetland is located between latitude 30° 22' 02" – 31° 36' 16" N and longitude 30° 29' 00" - 31° 21' 19" E. The catchment altitudes vary from zero level at Mediterranean Sea in the north to about 20 m at the most southern edge. The surface slope in the catchment area is northward with an average slope of 0.0015 m m^{-1}. It covers an area of about 5000 km^2 (El-Shinnawy 2002).

The groundwater pressure is called piezometric head, while the subsoil phereatic surface of clay cap is called shallow water table. Both water heads fluctuate around the year. The groundwater piezometric heads depended mainly in the past on the Nile water levels, while now they depend on the irrigation practices on a regional scale. The shallow water table fluctuates in response to local irrigation practices, seepage from adjacent canals, and field drainage depth. The difference in the levels between the piezometric heads in the aquifer and the water table causes the vertical water movement through the clay cap. The direction of movement is determined by which level is higher compared with a common reference plain. A water table level higher than the piezometric level indicates a downward movement. By contrast, when the piezometric level is higher, there is a potential for upward movement of the groundwater from the aquifer to the clay cap. Applying this phenomenon to the north of the catchment area where the difference in levels of groundwater head and shallow water table causes upward flow through the clay cap.

The catchment area can be divided on the basis of the above analysis into three zones: 1- the downward movement zone in the south, 2- upward movement zone to the north, and 3- the seawater intrusion zone along the seashore. In the downward movement zone, the aquifer is replenished by deep seepage of surface water to the aquifer. In this zone, salinity of shallow groundwater is higher than that of deep groundwater because the salts are leached by irrigation water. The drainage rate in this zone is low due to the natural drainage component provided by the downward movement. In the upward movement zone, the salinity of groundwater is higher due to the dispersion of the neighboring seawater. The upward flow of the brackish water causes increase of the drainage rates and their salinity in the northern drainage sub-catchments. The drainage system in this area receives simultaneously surface and groundwater flow.

The upward flux was estimated as 97 million m^3 yr^{-1} (based on a permeability coefficient of 4 mm day^{-1}), while the upward flow area was about 4200 km^2 (El-Shinnawy 2002). The net downward flux in 1988 was about 667 million m^3 yr^{-1}. This rate of downward flow is a maximum in most southern parts of the catchment area due to the small thickness of the clay cap, increase of soil permeability and the maximum difference between existing heads. The natural drainage diminishes towards the north due to gradual changes in these governing factors.

1.5.3. Groundwater Utilization

Groundwater is mainly abstracted for domestic and agricultural uses. Abstractions for industries probably cover a minor part of the total abstraction. Deep wells usually feed a piped drinking water supply system (serving a municipally or a rural unit) or irrigation canals at the end tails of irrigation system. They generally have depths of up to 70 m with a screened section of 20 – 30 m. Shallow wells operated by hand pumps are still extensively used for domestic purposes, especially in the rural areas of the catchment area. Shallow wells may have depths from 5 to 25 m below ground surface. Hand pump wells are usually drilled until sandy or gravelly sediments are reached, which often coincides with the top of the aquifer. Intercalated sandy layers within the top layer may also be pumped by hand pumps.

1.5.4. Groundwater Quality

The previous studies on groundwater quality in the catchment area, as a part of Nile Delta, dealt with nitrogen, iron, manganese and salinity hazards. Nitrate is almost absent in the groundwater aquifer at the catchment area, probably due to thick covering clay layer and thus long travel times. Iron and manganese have been found at random locations in groundwater aquifer throughout the floodplain. However, relationships could not be assessed

between concentrations and distance to pollution sources or with the depth below ground level. On the contrary, these metals are present only in very low concentrations in sandy areas compared to the clayey areas. The irrigation and drainage waters generally contain relatively low concentrations of iron and manganese. Therefore, sources of these metals are expected to originate from the lower horizons of the covering clay layers. Moreover, there is no inter-relation between iron and manganese concentrations (El-Shinnawy 2002).

The original WHO guidelines for Fe and Mn are 0.3 and 0.1 mg l^{-1}, respectively. On the other hand, the Egyptian guidelines are 1.0 and 0.5 mg l^{-1}, respectively. The salinity of groundwater is reasonably low in the southern parts of the catchment area, where values of salinity are less than 600 ppm. Northwards at the Middle Delta, the salinity increases quickly. The rate of increase is faster near the coastal zone, where salinity as high as 45000 ppm was recorded.

1.5.5. Water Resources

1.5.5.1. Rainfall

The mean annual rainfall over the area is 187.4 mm. This depth of water provides the lake with a mean annual volume of about 77.4 million m^3. Most rainfall takes place during the winter season (October – March), with no rainfall during summer months. The maximum depth of rainfall is received in December and January.

Table 1.11. **Monthly mean rainfall (mm) and rain volume (10^6 m^3) over Lake Burullus (after El-Shinnawy 2002).**

Month	Rainfall (mm)	Rain volume (x 10^6 m^3)
Jan	48.1	19.7
Feb	32.7	13.1
Mar	16.7	6.9
Apr	4.6	1.9
May	1.5	1.6
Jun	0.0	0.0
Jul	0.0	0.0
Aug	0.0	0.0
Sep	0.6	0.3
Oct	7.8	3.2
Nov	28.0	11.5
Dec	48.8	20.0
Annual	**187.4**	**77.4**

1.5.5.2. Drainage discharges

The drainage system provides the lake with about four billion $m^3\ yr^{-1}$ of agricultural drainage water. The maximum rate of water discharged to the lake is during rice cultivation season (July – September), while the minimum rate is in January and February (Table 1.12). Drain 9 discharges the maximum amount (about 20 % of the total volume), while Burullus Drain discharges the minimum (about 1.7 % of the total volume).

1.5.5.3. Tidal effect

The tide at Burullus headland was estimated as the difference between the mean high water level of 33 cm and the mean low water level of 18 cm. The 15 cm difference is small and hence the tidal effect would be negligible (Fanos 1992, as quoted by El-Shinnawy 2002). This conclusion works all over the year, but the mean high water level should be considered in the days of winter closure.

Table 1.12. **Monthly inflows of drainage discharges to Lake Burullus (million m^3).**

Month	Terah	Buru-llus	Drain 7	Drain 8	Drain 9	Drain 11	West Burullus	Ghar bia	Pre mpal	Total	%
Jan	32.9	4.9	27.8	29.8	65.0	45.1	7.4	32.2	13.7	258.8	6.6
Feb	36.8	4.6	31.8	28.6	65.0	39.9	7.4	21.4	5.7	241.1	6.2
Mar	40.1	5.7	32.2	29.6	65.0	56.7	10.5	36.4	16.8	293.0	7.5
Apr	41.8	4.9	39.1	28.6	65.0	51.2	9.0	33.1	14.4	287.1	7.4
May	55.6	5.0	36.6	32.7	65.0	65.5	12.7	31.5	16.4	321.0	8.2
Jun	60.6	4.4	44.5	37.3	65.0	78.2	16.6	48.5	15.5	370.6	9.5
Jul	72.6	5.9	51.3	48.5	65.0	85.0	18.2	60.2	17.0	423.6	10.9
Aug	72.3	6.3	52.0	49.6	65.0	77.6	17.4	52.4	18.0	410.6	10.5
Sep	64.1	6.8	48.2	41.9	65.0	71.9	14.1	60.0	23.3	395.4	10.1
Oct	46.7	5.8	39.5	33.1	65.0	56.7	9.8	44.0	19.1	319.7	8.2
Nov	42.9	5.6	36.6	33.2	65.0	53.8	9.9	32.4	20.3	299.5	7.7
Dec	43.1	6.0	36.5	33.0	65.0	41.5	6.8	33.6	18.8	284.3	7.3
Annual	**609.7**	**65.8**	**476.1**	**425.7**	**780.0**	**723.0**	**139.8**	**485.8**	**198.9**	**3904.6**	
%	**15.6**	**1.7**	**12.2**	**10.9**	**20.0**	**18.5**	**3.6**	**12.4**	**5.1**	**100.0**	**100**

1.5.5.4. Human activities

The human activities are represented by outflow/inflow of water from or to the lake by the local inhabitants in the surrounding areas. Social studies revealed that about 185 thousands person live and interact on daily basis with the lake. These inhabitants discharge their domestic effluents directly into the lake. Water consumption for such number of people (based on average rate of 150 $l\ day^{-1}\ capita^{-1}$) would be as much as 27750 $m^3\ day^{-1}$ (approximately

10×10^6 m^3 yr^{-1}). This water volume would be considered in evaluating the water budget of the lake.

1.5.5.5. Flow of groundwater

To evaluate the groundwater inflow and outflow from Lake Burullus, El-Shinnawy (2002) used a three-dimensional flow model based on the finite element method with triangular element and linear shape function. The model is capable of simulating the interaction between surface water bodies and groundwater aquifer systems. The numerical simulation results indicate that the groundwater inflow into Lake Burullus area is about 88902 m^3 day^{-1} (= 2667060 m^3 $month^{-1}$). The net upward flux to the bottom of the lake is about 63141 m^3 day^{-1}, while the net leakage through the lake boundaries is about 25761 m^3 day^{-1}. The total dissolved solids (TDS) of groundwater reaching the lake from the aquifer are about 16000 ppm.

1.5.5.6. Evaporation

The mean annual evaporation is 1583.3 mm. This value approximates about 646.5 million m^3 of water loss from Lake Burullus. Maximum evaporation takes place during May – September, while the minimum during December – February (Table 1.13).

Table 1.13. **Average daily and monthly evaporation (mm) and monthly volume of water loss (10^6 m^3) at Lake Burullus.**

Month	Daily (mm)	Monthly (mm)	Monthly volume (10^6 m^3)
Jan	3.6	110.7	45.4
Feb	3.9	108.9	44.7
Mar	4.2	131.1	53.5
Apr	4.6	138.6	54.4
May	4.9	151.9	62.3
Jun	4.8	143.1	58.7
Jul	4.8	147.3	60.4
Aug	4.7	144.5	59.2
Sep	4.7	139.8	57.3
Oct	4.3	134.2	55.0
Nov	4.0	118.5	48.6
Dec	3.7	114.7	47.0
Annual	**4.0**	**1583.3**	**646.5**

1.5.5.7. Outflow to the sea

Simulation of the outflow from the lake to the sea was implemented in two different cases (El-Shinnawy 2002). The first case presented the flow from the drainage system over the last four years where the High Dam releases continued without any winter closure. In this case, results indicate that water table was always above mean sea water level (Table 1.14). The elevation of

water varied from 28 cm (in February) to 61 cm (in August) above sea level. In this case only, water discharges from the lake to the sea.

The second case presented the usual case of the irrigation system in Egypt that enhances an annual winter closure. In this case, simulation was made by allowing no discharges from the drainage system to the lake during winter closure (in January). Results indicate that water level goes below sea water level by about 26 cm. This case allowed a volume of 110.7 million m^3 of sea water to move into the lake as a result of the winter closure (Table 1.14).

Table 1.14. **Results of flood routing in Lake Burullus. dH: change in water head.**

Month	Without winter closure			With winter closure		
	dH (cm)	Cum.dH (cm)	Total Storage (10^6 m^3)	dH (cm)	Cum.dH (cm)	Total Storage (10^6 m^3)
Feb	28	28	113.5	28	28	113.5
Mar	3	31	127.3	3	31	127.3
Apr	3	34	137.8	3	34	137.8
May	2	36	147.2	2	36	147.2
Jun	9	45	184.9	9	45	184.9
Jul	10	56	228.0	10	56	228.0
Aug	6	61	251.8	6	61	251.8
Sep	- 5	56	229.4	- 5	56	229.4
Oct	- 8	48	196.4	- 8	48	196.4
Nov	- 5	43	174.7	- 5	43	174.7
Dec	- 5	38	155.5	- 5	38	155.5
Jan	- 8	30	124.3	- 36	2	6.0
Feb				- 28	- 26	- 110.7

1.5.5. Water Balance

A water balance is often used to estimate the magnitudes of unknown hydrologic components such as outflow and change in storage within the wetland. To evaluate the change in storage for Lake Burullus, the water budget was estimated as follows: dS/dt = Inflow- outflow, where dS/dt = change of storage within the wetland over a specified time interval, inflow represents water bodies contribution to the lake, and outflow represents water losses and water interaction with the sea.

Results of the annual water balance indicate that the drainage water contributes about 97 %, while the contribution of rainfall is less than 2% and groundwater is less than 1% of the total water resources in the lake ecosystem (Table 1.15, Fig. 1.17). On the other hand, evaporation losses represent about 16% of the total water resources in the system, while the drainage system discharges about 3.2 billion m^3 to the sea through the lake (it represents, in

addition to the change of storage in the reservoir, about 84% of the total water resources in the system).

Table 1.15. **Results of the water balance in Lake Burullus). EV: evaporation, GW: groundwater, dS: change in storage, and H: water head.**

Month	Water gain (10^6 m^3)				Water loss (10^6 m^3)		dS (10^6 m^3)	Total H (cm)
	Drainage	Rainfall	Human	GW	EV	Outflow		
Jan	258.8	19.7	0.83	2.67	45.4	111.5	116.3	27
Feb	241.1	13.4	0.83	2.67	44.7	217.7	21.6	30
Mar	293.0	6.9	0.83	2.67	53.8	233.3	13.4	33
Apr	287.1	1.9	0.83	2.67	54.4	241.1	14.0	35
May	321.0	0.6	0.83	2.67	62.3	251.4	36.2	44
Jun	370.6	0.0	0.83	2.67	58.7	298.1	43.9	55
Jul	423.6	0.0	0.83	2.67	60.4	337.0	23.2	61
Aug	410.6	0.0	0.83	2.67	59.2	370.7	-23.4	55
Sep	395.4	0.3	0.83	2.67	57.3	339.6	-35.6	47
Oct	319.7	3.2	0.83	2.67	55.0	290.3	-29.1	42
Nov	299.5	11.5	0.83	2.67	48.6	282.5	.24.3	37
Dec	284.3	20.0	0.83	2.67	47.0	248.8	-0.8	37
Annual	3904.6	77.4	9.99	32.0	646.7	3221.9	155.4	
%	97.0	1.9	0.25	0.8	16.1	80.1	3.9	

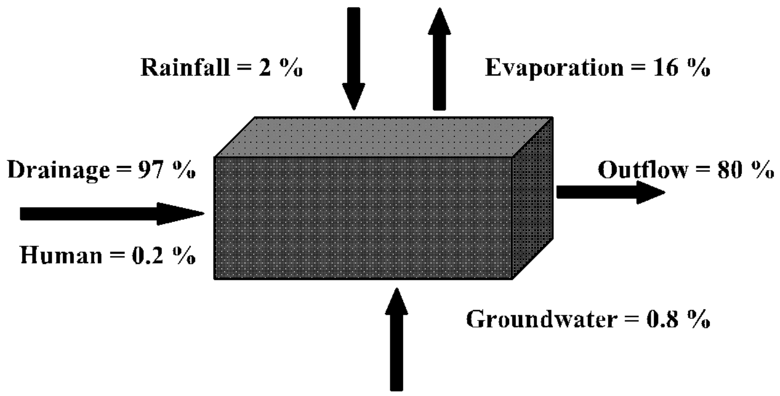

Fig. 1.17. Water balance in Lake Burullus

In order to re-establish the equilibrium status of salt balance in the lake, 84% of the water resources should be discharged outside the lake. This represents about 3.4 billion m^3 annually. This volume of excess water resources within the system makes water level in the lake during the whole year above the mean sea level. Accordingly, the salt balance in Lake Burullus has been deteriorated. In order to make use of this huge amount of drainage water, it is

recommended to convert this water to the areas of development projects at the east of the lake and to make use of Al-Moheet Drain to discharge water outside the lake.

Volumes of outflow and change of storage (dS) represent monthly excess water to be used in developing plans. The negative sign in the dS column in Table 1.15 does not represent low levels below the mean sea levels, but it means that outflow is greater than the net inflow in a specific time interval. Due to the winter closure in January, water level in the lake becomes below the sea level with about 26 cm. This case allows sea water to move into the lake with a volume of about 110 million m^3.

1.6. HABITAT TYPES

Six major types of habitat are recognized in Burullus Wetland: the salt marshes, sand formations, lake cuts, drains, lake proper and islets of the lake (Fig. 1.18). The following statements are a brief description of these habitats including the physical and chemical features of their soils.

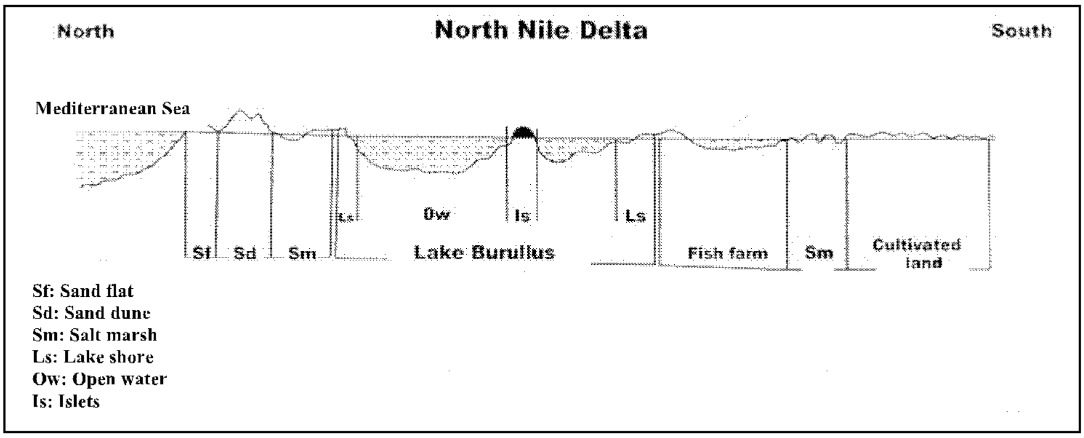

Fig. 1.18. **Major types of habitat in Burullus Wetland (after Ahmed 2003).**

1.6.1. Salt Marshes

Coastal salt marshes are lowlands near the coasts, covered with water during high tide, have increasing salinity particularly with the increase of evaporation rate, and covered with salt tolerant plants of high capacities for trapping and fixing soil deposits. They extend along the marine bar of Lake Burullus with an area that approximates 40% of the total area of the bar (6% in the eastern part, and 34% in the western part). Tidal action is considered among the principal factors responsible for the formation and development of salt marshes along the marine bar of Lake Burullus. With the extension of water during high tide and retreating during ebb-tide, and with the gentle sloping of the

shore, tidal waters extend to cover vast areas that increase with the happening of storm waves. Natural vegetation plays an important role in the development and evolution of salt marshes as it leads to increase evaporation rate and salinity. Moreover, the heavy growth of salt tolerant plants traps the deposits and help in leveling up the beds of the marshes (e.g. *Halocnemum strobilaceum*).

1.6.2. Sand Formations

Three types of sand formations cover the surface of the marine bar of lake Burullus: sand sheets (or flats), hillocks and dunes. The sand sheets cover vast area of the marine bar particularly along the north-western margins of the lake. These sheets have a few undulations and sometimes form the so called "sand ripples". Sand hillocks are embryonic dunes with height range between a few centimeters and a few meters. They have domal or longitudinal shapes. Their windward sides are covered by some herbs and shrubs (e.g. *Tamarix nilotica*) that help in the fixation of these hillocks. When the hillocks approach each other, they merge together to form large dunes covered by dense vegetation. Sand dunes in the marine bar of Lake Burullus represent the principal geomorphological feature affected by the sedimentation processes. Natural factors helped in presence of this geomorphological feature, where a close relation was found between the locations of the sand dunes and the ancient Nile Deltaic branches. The coastal sand dune formations are desertic sands that came from the western desert where the predominant western winds helped in their formation after mixing with the Nile deposits of the ancient Nile Deltaic branches and the marine deposits carried by the marine currents, particularly in the north eastern part of the marine bar (El-Bayomi 1999).

1.6.3. Lake Cuts

This habitat represents the recent lands resulted after the drying process that took place along the shores of Lake Burullus, particularly the outermost western and eastern fringes, during the period of 1984 to 1997. Some of these lands were used in construction of human settlements (e.g. Sidi Ibrahim El-Disouky and Sidi Ahmed Al-Badawey villages west of Mastaruh) and some others were reclaimed for cultivation: field crops, grapes and watermelons or as fish farms. Some other dried parts are still fallow and were subjected to secondary plant succession.

1.6.4. Drains

Most of cultivated lands in Egypt are irrigated by the Nile through a net of irrigation canals, and drained by a similar net of drainage canals. Land drainage has played an important role in agriculture developing in Nile Delta. Typically, the soil needed to be drained because of high water table, poor surface drainage, slow movement of water through the soil profiles and the need to minimize the salt level of the soil. Six drains discharge their water into the Lake

Burullus; mainly at its southern border. These are: Al-Gharbiyyah drain (connected with the lake through Al-Burullus and Ash-Sharikah drains in the eastern part), drain 7 (connected with Nassir, Nasr and Tirah drains), drain 8, drain 9 (connected with Bahr Nashart Drain), drains 10 and 11 in the south-western part. These drains discharge their water into the lake through water pump stations. The drains, as a major habitat, were classified into four microhabitats (i.e. zones): terraces, slopes, water-edge and open water (Fig. 1.19).

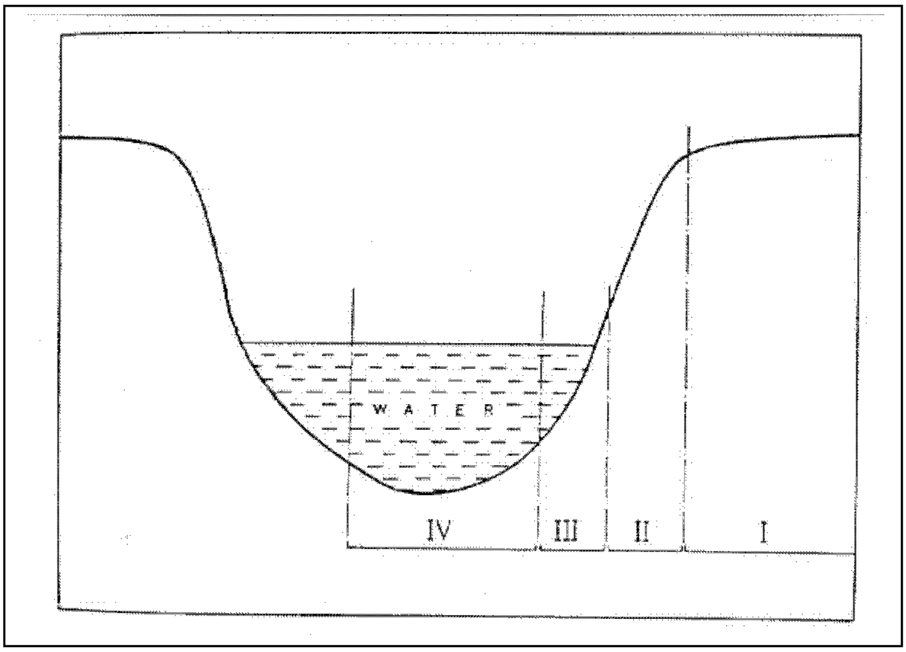

Fig. 1.19. **The four zones of the drains. I: terrace, II: slope, III: water edge, IV: open water.**

1.6.5. Lake Proper

Lake Burullus has an oblong shape, it extends for a distance of 47 km along NE-SW axis. The lake proper is classified into two habitats: lake shore and open water. The shoreline takes several forms related basically to its formation, origin and evolution The width of the open water of the lake from north to south varies from site to another. The western sector has the least width which does not exceed 5 km, then it increases in the middle sector to reach an average of 11 km. As the area of the lake changed with time, its dimensions changed also. Vast areas of the water surface are covered with the emergent common reed (*Phragmites australis*), and the submerged sago pondweed (*Potamogeton pectinatus*).

1.6.6. Islets

Many islets with different sizes are distributed in Lake Burullus. Due to the continuing of the effects of the geomorphological processes (e.g. sedimentation, erosion and water flooding), the number, size, dimensions and locations of these islets change from time to time. They move from their locations or merge together when become close to each other. The heavy growth of reeds and sedges (e.g. *Phragmites ausralis* and *Typha domingensis*) facilitates the merging of the nearby islets. They could be classified according to their shapes into different groups : longitudinal (e.g. Dibar), circular or oval (e.g. El-Zanka), triangular (e.g. Doshimi), arc (e.g. shishet Al-Agoza), curved (e.g. El-Zoaya) and irregular (El-Maghara and Absak). Many islets have obvious longitudinal extensions parallel with the directions of the prevailing western winds, their axes usually extend from north to south, and occasionally from north to east. The surface levels of some islets approach 3 meters above water level, thus they are called hills or piles where some remains of settlement centers related to Romanian era are still found over some of them (e.g. Singar islet in the eastern sector). The surface levels of some other islets (e.g. El-Zanka, Farash El-Toob and El-Dakhla in the middle sector) approach the water level of the lake, sometimes the water submerges them particularly during the increase of water flow from the sea and drains.

1.6.7. Soil Characteristics

Physical and chemical characteristics of the habitats indicate that the soil of sand formations is characterized by high values of phosphorus (43.0 mg $100g^{-1}$) and low values of silt (0.5%), organic matter (0.3%), calcium carbonate (2.1%), pH (7.5), nitrogen (16.4 mg $100g^{-1}$), sodium (142 mg $100g^{-1}$), potassium (22.8 mg $100g^{-1}$) and magnesium (157 mg $100g^{-1}$) (Table 1.16). Soil of the drain slopes is characterized by the highest values of clay (16.2%) and calcium carbonates (10.9%), but the lowest of iron (6.8 mg $100g^{-1}$), and that of water edges is characterized by high values of electric conductivity (11.0 mS cm^{-1}), nitrogen, sodium and calcium (93.9, 794 and 1618 mg $100g^{-1}$, respectively), and low of sand (60.9%). Soil underneath the open water zone of the drains has the highest values of silt (29.8%), organic matter (5.4%), pH (8.1) and potassium (309 mg $100g^{-1}$) and low of phosphorus (13.1 mg $100g^{-1}$). On the other hand, soil underneath the open water zone of the lake has high value of pH (8.1) and low of electrical conductivity (1.5 mS cm^{-1}), phosphorus (4.9 mg $100g^{-1}$) and calcium (355 mg $100g^{-1}$). Soil of lake shore is characterized by high values of sand (87.6%), magnesium and iron (339 and 20.6 mg $100g^{-1}$), and that of salt marshes is characterized by high values of phosphorus (43.1 mg $100g^{-1}$).

Table 1.16. **Means (first line) and standard deviations (second line) of some soil characters collected from represented stands of the main habitats of Lake Burullus area. The habitats are: SM: salt marshes, SS: sand formations, LG: lake cuts, TD: terraces, SD: slopes, ED: water edges and OD: open water zones of the drains, LS: lake shores and LO: open water of the lake.**

Soil variables		Habitats									Mean
		SM	SS	LG	TD	SD	ED	OD	LS	LO	
Clay		13.0	12.2	13.4	10.4	16.2	13.0	9.1	9.2	9.3	12.3
		2.7	2.5	4.1	4.8	24.5	7.2	7.2	3.8	3.3	10.6
Silt	%	5.2	0.5	1.0	15.3	17.1	26.1	29.8	2.7	4.6	13.6
		9.7	0.6	1.4	15.6	14.3	15.5	16.0	3.8	5.6	15.7
Sand		82.0	87.4	85.5	74.3	71.7	60.9	61.1	87.6	86.1	74.9
		10.1	2.4	4.5	13.8	14.5	16.0	17.7	7.3	8.1	15.8
O.M.		1.1	0.3	0.9	3.1	3.1	4.3	5.4	1.1	1.4	2.4
		1.3	0.1	0.6	3.4	2.8	2.5	5.7	0.7	0.4	3.1
CaCO3		2.3	2.1	2.5	3.1	10.9	2.5	3.7	4.1	4.3	4.1
		0.3	0.3	0.5	4.8	40.8	1.4	2.1	6.6	2.0	15.7
EC (mS cm^{-1})		4.6	2.8	2.7	2.9	5.9	11.0	2.9	3.5	1.5	5.0
		2.6	0.9	1.9	2.0	5.6	10.5	2.7	1.7	0.6	5.8
pH		7.7	7.5	7.7	7.9	7.9	7.8	8.1	8.0	8.1	7.8
		0.3	0.2	0.2	0.3	0.2	0.3	0.4	0.3	0.4	0.3
N		25.2	16.4	27.4	56.0	34.9	93.9	75.8	39.7	67.9	51.0
		21.1	9.2	18.5	64.9	44.4	67.5	72.4	24.8	32.0	55.4
P	mg $100g^{-1}$	43.1	43.0	25.7	38.3	30.9	27.6	13.1	42.6	4.9	33.3
		16.7	15.1	9.2	16.7	13.2	16.8	7.2	4.6	2.6	18.1
Na		383	142	213	678	438	794	718	469	480	531
		479	91.9	124	620	199	308	287	253	182	434
K		58.2	22.8	28.3	183	161	197	309	98.3	184	143
		86.1	7.7	6.8	182	129	105	80.8	67.3	65.4	136
Ca		1396	750	1498	1402	1536	1618	517	1081	355	1277
		905	115	691	1271	919	1156	385	699	105	981
Mg		236	157	182	251	274	284	285	339	166	254
		155	43.3	55.0	97.4	58.0	155	94.2	167	63.9	124
Fe		13.0	10.9	14.8	7.8	6.8	14.9	10.9	20.6	10.4	11.9
		11.1	3.3	8.4	5.1	5.0	17.4	18.3	24.2	1.5	13.1

1.7. BIOTIC COMMUNITY

Based on ecosystem approach (Fig. 1.20), the biotic community in Lake Burullus is classified into three major groups: producers, consumers and saprotrophs. The producers are classified into vascular plants and phytoplankton (i.e. algae). The consumers are classified into three trophic levels: primary consumers (i.e. herbivores), secondary consumers (i.e. primary carnivores) and tertiary consumers (secondary carnivores). Zooplankton and zoobenthos are mainly primary consumers, but the other animal groups (terrestrial invertebrates, fishes, reptiles, amphibians, birds and mammals) have members that belong to the

three levels of consumers. The saprotrophs are mainly the bacteria and fungi of decay.

1.7.1. Producers

A total of 197 species of vascular plants have been recorded from Burullus Wetland (100 annuals and 97 perennials) including 11 hydrophytes (the most common is *Potamogeton pectinatus*) and one fern (*Azolla ficliculoides*). The most common of all these species is the common reed *Phragmites australis*. With 35 species (i.e. 18 % of the total species), the grasses are the predominant component of the species composition (Shaltout & Al-Sodany 2000). The phytoplankton community includes some 226 algal species: 125 Bacillariophytes (Diatoms), 56 Chlorophytes, 39 Cyanophytes, 2 Euglenophytes, 2 Dinophytes, one Cryptophyte and one Rhodophyte. The first three major groups are arranged according to their biomass as follows Bacillariophytes (69 %), Chlorophytes (16.2 %) and Cyanophytes (14.8%); and according to their numbers as follows: Chlorophytes (58.9%), Bacillariophyes (31%) and Cyanophytes (8.8%). The other groups had a minor contribution (El-Sherif 1993). The common submergent *Potamogeton pectinatus* is a host for some 45 epiphytic algal species, most of them are limnetic forms and can survive in both planktonic and attached situations (Samman *et al.* 1988).

1.7.2. Consumers

The zooplankton community in Lake Burullus includes 54 species of: Rotifera (35 species), Copepoda (9 species) and Cladocera (10 species). All of these species are of freshwater origin. The zooplankton community is dominated by 8 species, while the rest are either rare or very rare (El-Shabrawy 2002). In a previous study by Aboel Ezz (1995) the zooplankton community of the lake was estimated as 90 species: 26 species of Copepoda, 7 of Cladocera, 26 of Rotifera and 10 of Protozoa; they constitute collectively about 85% of the total zooplankton. Other infrequent forms (21 species: 15%) were also recorded, beside ciripede larvae, larval stages of decapods, insect larvae, polychaete larvae, veligers of molluscs and free living nematodes.

The study of terrestrial invertebrates in Burullus Wetland is still at a preliminary stage. Specimens of 23 species representing 4 orders of spiders, scorpions and their allies (Araneida, Pseudoscorpionida, Scorpionida, Solpugida) have been collected (El-Hennawy 2000). In addition 94 insect species were recoded so far in this region, however it is believed that this number will be increased substantially on more thorough investigation (Metwally 2000).

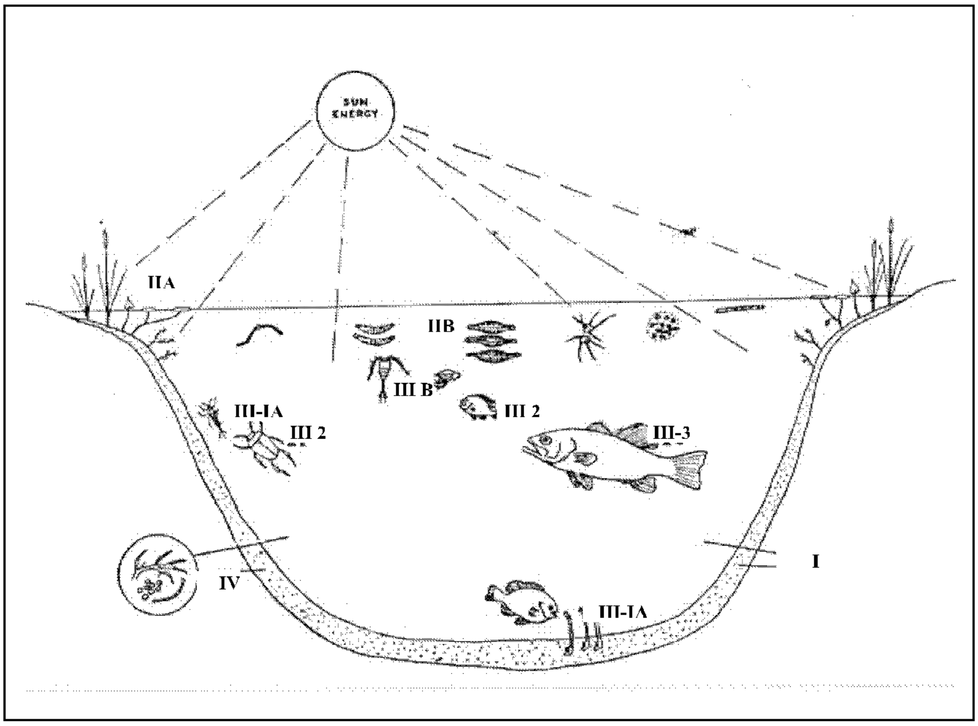

Fig. 1.20. **Diagram of Lake Ecosystem. Basic units are as follows: I: abiotic substances-basic inorganic and organic compounds, IIA: producers-rooted vegetation, IIB: producers-phytoplankton, III-IA: primary consumers (herbivores)-bottom zoobenthos, III-B: primary consumers (herbivores)-zooplankton, III-2: secondary consumers (primary carnivores), III-3: tertiary consumers (secondary carnivores), IV: saprotrophs-bacteria and fungi of decay. The metabolism of the system runs on sun energy, while the rate of metabolism and relative stability of the lake depend on the rate of inflow of materials from rain and from the drainage basin in which the lake is located (modified from Odum 1971).**

The present fish population in Lake Burullus includes of 25 species, 15 of which live in fresh or brackish water. Of the remaining 10 species, four (*Sparus aurata, Johnius hololepidotus, Solea solea* and *Liza saliens*) are of purely marine origin which invade the lake for some time. The remaining six species (*Aphanus fasciatus, Atherina mochon, Anguilla anguilla, Mugil cephalus, Liza ramada* and *Gambusia affinis*) belong to a separate group of obligatory migrants which spend their adult life in the brackish water of the lake and migrate to the sea for spawning (Khalil & El-Dawy 2002).

There are 22 species of reptiles and amphibians in Burullus Wetland. The recently described Nile Valley Toad *Bufo kassasii* is endemic to Egypt with

localized distribution in Nile Valley, but it is found in dense populations in suitable freshwater swamps along the southern margins of Lake Burullus (Anonymous 2002). The isolated population of Audouin's Shink *Sphenops sepsoides* is widespread Saharan inhabitant of sandy biotopes and common elsewhere in Egypt; it is under threat as a result of the destruction of sand dunes. The relict population of Javelin Sand Boa *Eryx jaculus* is under a similar threat. There are 2 globally endangered reptile species occurring in Burullus Wetland: Loggerhead Turtle *Caretta caretta* and Green Turtle *Chelonia mydas*.

One hundred and twelve species of birds were recoded in Burullus Wetland. Burullus is home to six bird subspecies endemic to Egypt, none is considered threatened: Little Green Bee-eater *Merops orientalis cleopatra*, Laughing Dove *Streptopelia sengalensis aegyptiaca*, Senegal Coucal *Centropus sengalensis aegyptius*, Egyptian Swallow *Hirunda rustica savignii*, Crested Lark *Galerida cristata nigricans* and Egyptian Yellow Wagtail *Motacilla flava pygmaea*. The Egyptian forms of the Laughing Dove and The Swallow are two of the most abundant birds in Egypt. The Egyptian Yellow Wagtail breeds in or at the edge of wetlands and therefore has rather narrow habitat requirements – which are met at Burullus. Five rare species and subspecies occur at Lake Burullus (Goodman *et al.* 1989): Montagu's Harrier *Circus pygargus*, Cuckoo *Cuculus canorus canorus*, Bar-tailed Godwit *Limosa lapponica lapponica*, Pied Avocet *Recurvirostra avosetta* and Jack Snipe *Lymnocryptes minimus*.Two of the bird species occurring in Burullus Wetland are globally threatened: Lesser Kestrel *Falco naumanni naumanni* and Ferruginous Duck *Aythya nyroca*.

A total of 15 mammal species have been recorded from Burullus Wetland. Of these, only one species (Flower's shrew, *Crocidura floweri*) is rare and endemic to Egypt. According to the status categories set out by IUCN, two species (*Canis aureus* and *Felis chaus nilotica*) are cosidered vulnerable (Basuony 2000).

1.7.3. Saprotrophs

The aquatic bacteria and fungi are distributed throughout the rivers, ponds and lakes, but they are especially abundant in the mud-water interface along the bottom where bodies of plants and animals accumulate (Odum 1971). The available data on both biotic groups in Lake Burullus are too limited; only 3 papers were recently published in 2002 and 2004. The first paper deals with the zoosporic fungi recovered from 3 northern lakes (Edku, Burullus and Manzala) and lake Qaron (Mahmoud & Abou Zeid 2002). The second one was published by El-Hissy *et al.* (2004) on the diversity of zoosporic fungi recovered from the surface water of four lakes including Burullus and Manzala in the north, Qaron in the Mid and Nasser in the south. The third deals with the distribution of some actinomycetes groups in Lake Burullus (Abou-Elela *et al.* 2004). No doubt that

this gap of information should be filled taking into account the important biological role of the saprotrophic organisms in the dynamics of aquatic ecosystems.

1.8. BIOTIC RESPONSES TO RECENT ENVIRONMENTAL CHANGES

Birks *et al.* (2001) studied the biotic responses of Lake Burullus to recent environmental changes using short sediment core of one meter depth, which usually represents the last hundred years. This core was classified into three zones. In zone 1 (36 – 66 cm), salt marsh is indicated by abundant Chenopodiaceae pollen (Peglar *et al.* 2001) and *Salicornia europaea* seeds. The water level may have been low before 1900, encouraging the outward spread of reed- and salt marsh. Macrophytes were few and *Azolla nilotica* floated on the surface. Animal remains suggest fresh or brackish water with only periodic marine incursions. The zooplankton and diatom assemblages in this zone also indicate fresh or slightly brackish water (Flower *et al.* 2001, Ramdani *et al.* 2001).

In zone 2 (16 – 36 cm), there is a marked local decrease of reed marsh and salt marsh macrofossil taxa and freshwater animals. However, the pollen record suggests a regional increase in salt marsh vegetation (Peglar *et al.* 2001). *Ruppia* expanded, accompanied by other macrophytes tolerant of brackish water, *Myriophyllum spicatum, Potamogeton pectinatus* and *Najas armata*. Lagoon molluscs, ostracods, and forams showed a major expansion. The abundance of shells in the sediments is reflected in the rise of carbonate from 5% to 20% at the top of zone 2 (Birks *et al.* 2000). The gastropod *Hydrobia musaensis* is characteristic of fresh and brackish water in Lower Egypt (Brown 1994). It is possible that a marine incursion around 1900 raised the water level, resulting in a major ecosystem change.

The brackish water community declined, probably after 1920. Around 1940 (zone 3a: 8 – 16 cm) fresh water influence is indicated by the expansion of freshwater molluscs and animals such as *Plumatella*. Lagoon molluscs and other brackish water animals, particularly ostracods and forams, remained abundant, however, reflecting continued, probably seasonal, marine influence. *Ruppia* and *Typha* may have been encouraged by eutrophication, and greater productivity is also suggested by the increases in fish remains and nereid jaws. Nereids were important members of the recorded benthic fauna in all the Delta lakes (Samaan *et al.* 1989) at least up to 1980. *Corbicula* was reported as the most abundant benthic mollusc in Lake Burullus but *Theodoxus niloticus* was confined to the north central area in 1978 – 1979 (Samaan *et al.* 1989). The gastropod *Melanoides tuberculata*, characteristic of bottom mud in disturbed

fresh and brackish lakes (Brown 1994), was frequently recorded living in the core site area in 1978 – 1979 (Samaan *et al.* 1989). *Biomphalaria alexandrina* and *Valvata nilotica* snails are rather intolerant of salinity (Brown 1994) and were present but rare. *Azolla nilotica* became extinct after 1960.

In zone 3b (0 – 8 cm), starting in 1963 (Appleby *et al.* 2001), fresh water influence increased. This coincides with the completion of Aswan High Dam. *Ruppia* was replaced by *Potamogeton pectinatus* is very abundant today. *Typha* marsh continued to expand near the coring site and freshwater animals increased, while brackish taxa declined. The large numbers of freshwater molluscs in the surface sediment reflect their living occurrence in the lake today. The spread of *Biomphalaria* in the Delta after 1965 is documented as it is a major carrier of bilharzia (Brown 1994). Lake Burullus was still brackish as shown by the occurrence of many lagoon molluscs in the surface sediments (Fathi *et al.* 2001). However, pollution and eutrophication have increased since 1965. Pb levels have risen in the top sediment (Birks *et al.* 2000). Increased nutrients are suggested by the occurrence of *Ceratophyllum* and the luxuriant growth of *Potamogeton pectinatus* and *Najas armata*. The diatom assemblage indicates brackish water with relatively stable salinity levels, suggesting that periodic marine influence was reduced (Flower *et al.* 2001). In conclusion, recent changes in Lake Burullus have been smaller than in the other Delta lakes, as a degree of salinity has been maintained. Previous changes in water level and marine influence have caused much larger changes in the lake ecosystem. However, declining water quality possibly threatens the fishing industry on the lake (Birks *et al.* 2000).

1.9. SUMMARY

Burullus Wetland (i.e. Burullus Protectorate Area) is located along the Mediterranean coast in the northern part of Nile Delta. It is bordered from the north by Mediterranean Sea and from south by the agricultural lands of northern Nile Delta. Burullus Wetland belongs administratively to Kafr El-Sheikh Governorate. It lies in a central position between the two branches of Nile: Damietta Branch to the east and Rosetta Branch to the west. The Protectorate includes the entire area of Lake Burullus with numerous islets insides it, as well as the sand bar that separates the lake from the Mediterranean Sea, with a shoreline of about 65 km. The total area of this Protectorate is 460 km^2.

The shoreline of Lake Burullus takes several forms related basically to its formation, origin and evolution. It has an oblong shape, extends for a distance of 47 km along NE-SW axis. The width of the lake from north to south varies from site to the other. The western sector has the least width which does not exceed 5 km, then it increases in the middle sector to reach an average of 11

km. Lake Burullus had lost about 49% of its size along 112 years (from 1092 km^2 in 1801 to 556 km^2 in 1913), and about 62.5% by 1997 (410 km^2).

Lake Burullus is a shallow basin with a depth varies between 40 cm near the shores and 200 cm near the sea outlet (Boughaz El-Burullus). The field studies, using remote sensing, indicated that the deepest parts lie in the middle sector of the lake, where the depth reaches 200 cm, and also the southern parts of the western sector (west of Doshimi islet). The eastern sector is the shallowest, where the depth does not exceed 20 cm near the shore, but increases westwards until it reaches about 70 cm.

The main basin of Lake Burullus is classified into three sectors: eastern, middle and western; each one of them has some sort of homogeneity in the geomorphological, hydrological and biological characteristics. The islets scattered in the lake form physical isolations between these sectors.

The marine bar (i.e. sand bar) of Lake Burullus is the zone that separates the Mediterranean coast in the north from the lake shore in the south. It covers an area of about 165 km^2. Although the surface of this bar is relatively flat, but it has different geomorphological features that had been formed upon it as a result of the evolution and development of the geomorphological processes (sand flats, sand dunes, sand hillocks, salt marshes, tidal flats and sea outlet). Some of these features were related to the sedimentation process such as sand flats, sand dunes and sand hillocks; and some others were due to change of sea level like salt marshes and tidal flats.

Many islets with different sizes are distributed in Lake Burullus. Due to continuing the effects of the geomorphological processes (e.g. sedimentation, erosion and water flooding), the number, size, dimensions and locations of these islets change from time to time. They move from their locations or merge together when become close to each other. The recent number is 30 islets that take different shapes, such as longitudinal (e.g. Dibar), circular or oval (e.g. El-Zanka), triangular (e.g. Doshimi), arc shape (e.g. Shishet Al-Agoza), curved (e.g. El-Zoaya) and irregular (e.g. Absak).

The northern part of Nile Delta belongs to the Mediterranean arid region. The climatic conditions are warm summer (20 to 30 °C) and mild winter (10 to 20 °C). The aridity index (P/PET: where P is the annual precipitation and PET is the potential evapo-transpiration) ranges between 0.03 and 0.2 at the north Delta (arid region), and less than 0.03 at the south (hyperarid region). In general, the distribution of the mean annual rainfall in this region shows a maximum close to the Mediterranean coast (190.8 mm $year^{-1}$ at Rosetta) and then decreases rapidly toward the south. Most of the rain falls during winter ($\geq$ 80%), and only less 10% falls during spring.

Results of the annual water balance indicate that the drainage water contributes about 97 % (3.9 billion m^3), while rainfall contributes less than 2% (77.4 million m^3) and groundwater less than 1% of the total water resources in the lake ecosystem. On the other hand, evaporation losses represent about 16% of the total water resources in the lake (646.7 million m^3), while the drainage system discharges about 3.2 billion m^3 to the sea through the lake (it represents, in addition to the change of storage in the reservoir, about 84% of the total water resources in this system).

Six major habitats are recognized in Burullus Wetland: salt marshes, sand formations, lake cuts, drains, the lake and islets. Salt marshes extend along the marine bar of Lake Burullus with an area approximates 40% of the total area of the bar (6% in the eastern part, and 34% in the western part). Three types of sand formations cover the surface of the marine bar of lake Burullus: sheets (or flats), hillocks and dunes. Lake cuts represent the recent lands that resulted after the drying process that took place along the shores of Lake Burullus, particularly the outermost western and eastern fringes. The drains, as a major habitat, were classified into four microhabitats (i.e. zones): terraces, slopes, water-edge and open water. The lake proper is classified into two habitats: lake shore and open water.

A total of 197 species of vascular plants have been recorded from Burullus Wetland (100 annuals and 97 perennials) including 11 hydrophytes (the most common is *Potamogeton pectinatus*) and one fern (*Azolla ficliculoides*). The most common of all these species is the common reed *Phragmites australis*. Some 226 algal species were recorded: 125 Bacillariophytes (Diatoms), 56 Chlorophytes, 39 Cyanophytes, 2 Euglenophytes, 2 Dinophytes, one Cryptophyte, and one Rhodophyte. The zooplankton community of the lake was estimated as 75 species distributed as follows: 15 species of Copepoda, 9 of Cladocera, 39 of Rotifera, 8 of Protozoa and 4 meroplankton species. The biotic community includes also 33 aquatic macrobenthos, 118 species of the terrestrial invertebrates, 25 species of fishes, 22 of reptiles, 112 of birds and 15 of mammals.

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1.11. PLATES OF GENERAL CHARACTERISTICS (1.1 – 1.3)

(Photos were taken by K. H. Shaltout)

Plate 1.1:

- Guiding board of Lake Burullus Protectorate
- Cottages of Arab El-Mahder fishermen
- Barchan sand dunes (Marine sand bar)
- Complex sand dunes (sand bar near Baltim)
- Plastering the sides of the coastal dune near Baltim
- Longitudinal sand dune west the sea inlet

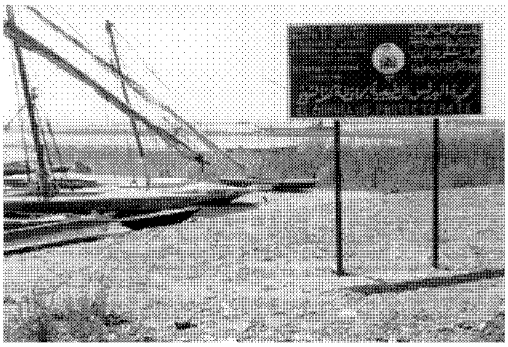
Plate 1.2:

- The bridge of Brimbal Canal
- A new village west of Lake Burullus
- Home ducks in Lake Burullus
- Drainage of the waste water of fish farms into the lake
- *Juncus acutus* along the shore of Al-Kawm Al-Akhdar islet
- Flow of water from the lake into the sea

Plate 1.3:

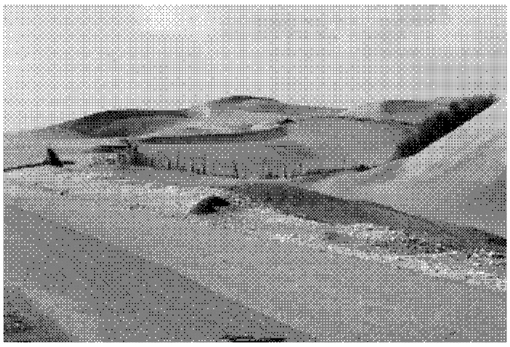
- Jetties at the sides of the sea inlet
- Mediterranean shore west of Burg El-Burullus
- Buffalo and ducks feed, drink and swim in Lake Burullus
- The erosion of the international road

Plate 1.1

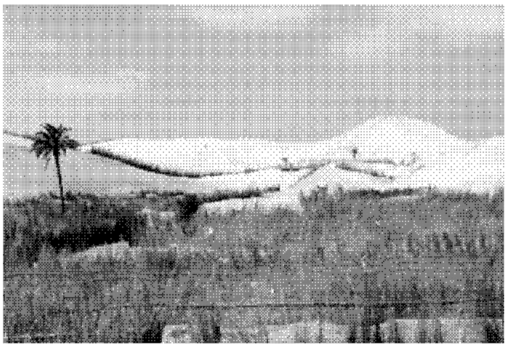


Guiding board of Lake Burullus Protectorate

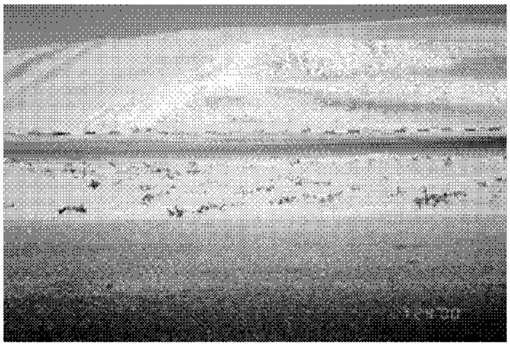
Cottages of Arab El-Mahder fishermen



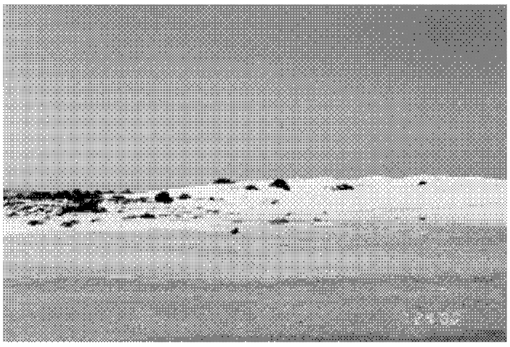
Barchan sand dunes (Marine sand bar)



Complex sand dunes (sand bar near Baltim)

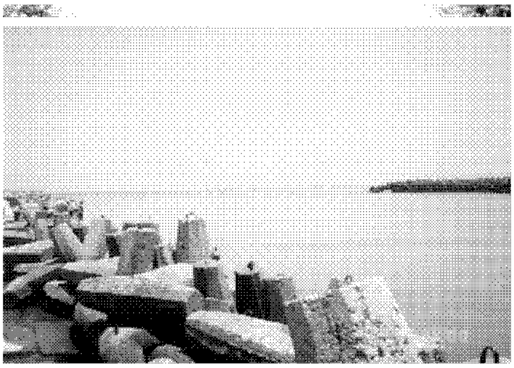


Plastering the sides of the coastal dune near Baltim



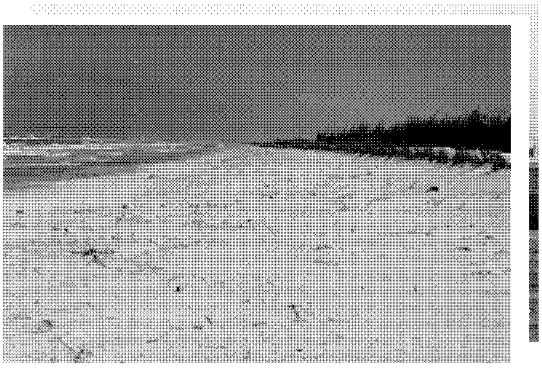
Longitudinal sand dune west the sea inlet

Plate 1.3



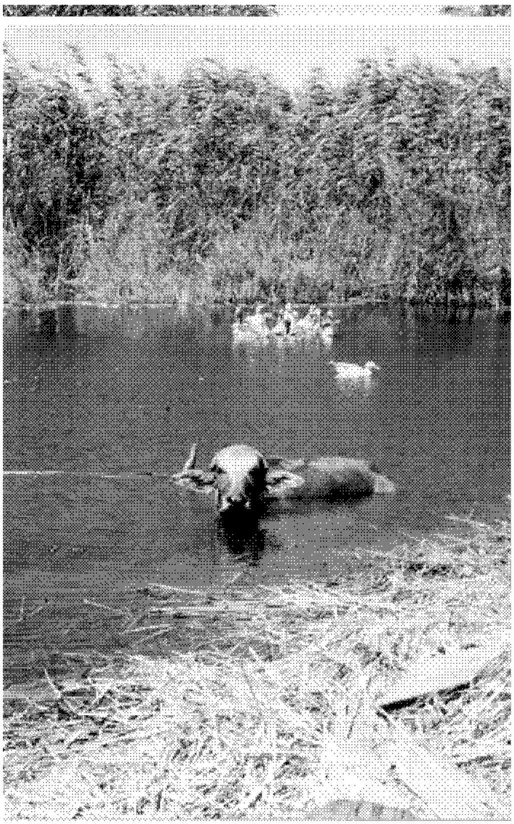
The bridge of Brimbal Canal

Jetties at the sides of the sea inlet

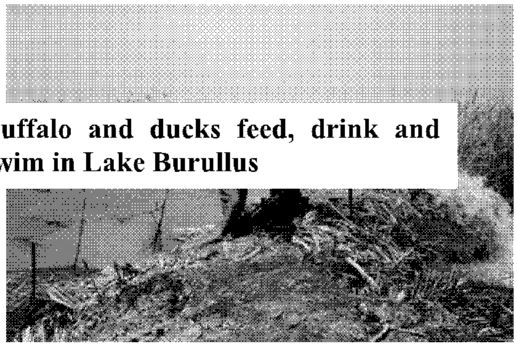


A new village west of Lake Burullus (Sidi

Mediterranean shore west of Burg El-Burullus

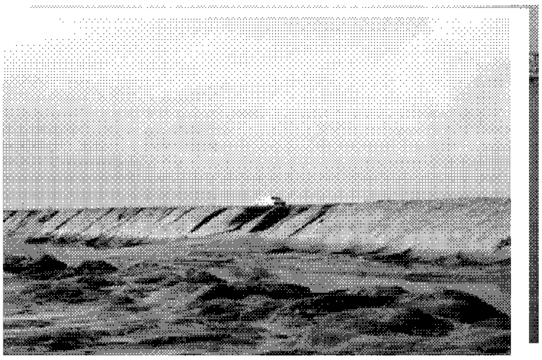


Juncus acutus along the shore of Al-Kawm Al-Akhdar islet



Buffalo and ducks feed, drink and swim in Lake Burullus

The erosion of the international road



Flow of water from the lake into the sea

Chapter 2
Water Properties

The water properties of Lake Burullus were evaluated based on one year monitoring (January – December 2001) for 15 stations representing the eastern, middle and western sectors of the lake (Fig. 2.1) (Radwan 2004). The estimated variables were classified into 4 main groups (*Sensu* Greenberg *et al.* 1992): physical and aggregate properties (air temperature, water temperature, transparency, depth, EC, pH, chlorosity and alkalinity), oxygen properties (dissolved oxygen, chemical and biological oxygen demands), dissolved salts (phosphate, nitrate, nitrite and silicate) and heavy metals (copper, iron, cadmium, lead and zinc). The variations were analyzed based on three aspects: 1- the annual means of the estimated variables in the 15 stations (Table 2.1), 2-the east-west variation (Table 2.2) and 3- the north-south variation (Table 2.3).

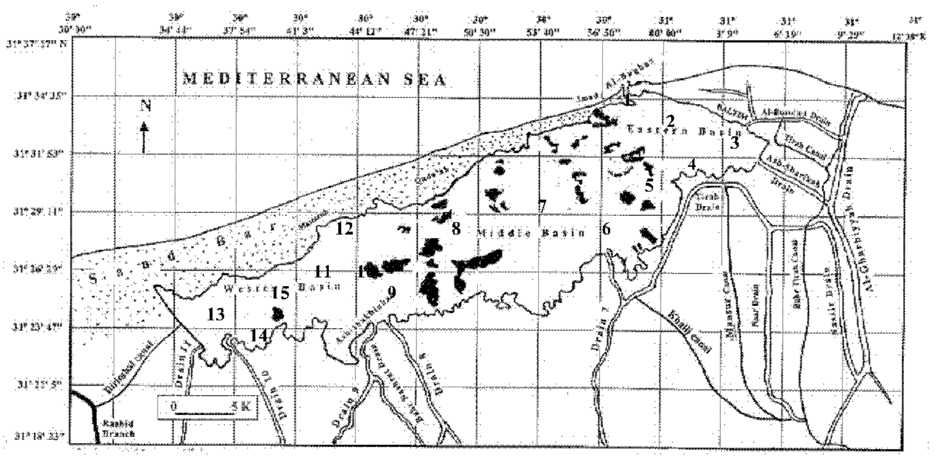


***Fig. 2.1.* Location of the 15 stations selected for the monitoring of the water and sediment properties in Lake Burullus**

Table 2.1. **Annual mean of water properties at 15 stations in Lake Burullus. DO: dissolved oxygen, COD: chemical oxygen demand, BOD: biological oxygen demand, SD: standared deviation. The minimum and maximum values of each variable are underlined.**

Variable	Eastern sector							Middle sector					Western sector			Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	mean±SD
Physical and aggregate properties																
Air temperature (°C)	23.0	23.8	23.3	23.5	22.5	22.8	22.3	21.3	22.7	22.8	22.8	22.2	24.2	24.0	23.0	22.9±4.8
Water temperature (°C)	22.5	22.8	22.2	21.9	22.4	22.9	22.9	22.4	22.8	22.2	21.8	22.0	22.6	23.3	23.0	22.5±5.2
Transparency (cm)	31.7	26.6	23.5	22.3	25.8	22.3	32.1	29.6	24.3	27.8	43.3	31.3	42.5	32.1	49.6	31.0±11.1
Depth (cm)	84.6	67.0	195.3	150.6	80.8	85.0	99.2	110.8	97.1	112.1	133.3	134.2	149.6	99.6	137.5	115.8±38.4
EC (mS cm^{-1})	16.8	6.4	4.8	5.3	5.1	5.6	14.5	3.2	3.0	3.1	2.8	3.3	3.1	1.6	2.3	5.4±4.8
Chlorosity (g l^{-1})	6.6	2.3	1.8	2.0	1.8	1.9	5.0	1.0	0.9	0.9	0.9	1.1	1.0	0.6	0.6	1.9±1.8
pH	8.7	8.5	8.6	8.4	8.8	8.8	8.9	8.7	8.6	8.6	8.7	8.7	8.5	8.4	8.7	8.6±0.6
Alkalinity (g l^{-1})	253.2	256.4	288.5	286.1	281.2	257.8	245.3	244.8	309.6	286.3	275.9	255.5	227.3	211.4	188.0	257.8±53.7
Oxygen properties																
DO	9.1	7.6	8.2	6.6	8.3	7.9	8.9	8.0	9.6	9.4	9.4	9.2	10.4	7.2	9.4	8.6±2.3
COD **mg l^{-1}**	4.1	5.1	4.9	4.4	4.7	5.4	4.5	3.6	5.1	3.5	4.0	5.3	4.9	5.3	3.9	4.6±1.7
BOD	3.3	4.2	4.0	3.8	3.4	3.9	3.4	2.8	4.6	2.9	2.7	3.2	3.8	4.3	3.7	3.6±1.6
Dissolved salts																
PO_4	0.6	1.7	2.2	2.7	1.0	2.2	0.8	0.6	1.6	1.0	0.6	1.2	0.7	1.9	0.7	1.2±1.1
NO_3	0.8	2.9	5.5	6.5	2.1	3.9	0.8	1.9	3.7	2.0	1.2	1.3	3.3	4.2	2.2	2.8±2.3
NO_2 **µg-at. l^{-1}**	0.3	1.1	1.5	2.0	0.8	1.3	0.2	0.5	1.4	1.0	0.8	0.7	1.4	1.5	1.2	1.1±0.8
SiO_3	36.0	37.6	35.0	41.1	29.8	36.0	42.9	37.3	45.0	42.5	49.9	40.8	49.3	49.8	51.9	41.7±25.1
Heavy metals																
Cu	7.1	8.2	8.8	8.4	3.2	8.7	6.4	3.0	6.8	3.0	3.5	2.6	5.4	8.3	5.1	5.9±4.0
Fe	9.6	6.6	10.8	13.7	4.9	8.9	6.7	2.9	5.4	2.5	1.9	2.7	5.3	7.8	4.1	6.2±6.2
Cd **µg-at. l^{-1}**	8.4	4.4	3.4	5.8	3.5	6.3	6.7	2.0	3.8	1.6	1.9	1.7	2.5	3.3	1.6	3.8±3.2
Pb	3.6	5.5	5.3	6.2	2.0	4.6	3.5	1.5	4.1	1.7	1.1	1.2	3.4	6.3	3.4	3.6±3.2
Zn	17.2	12.0	10.2	11.4	9.0	12.0	13.1	6.5	7.6	3.7	6.7	4.0	4.9	6.4	3.5	8.5±5.7

Table 2.2. Annual range, mean and standard deviation (SD) of water properties along east-west axis in Lake Burullus in 2001. DO: dissolved oxygen, COD: chemical oxygen demand, BOD: biological oxygen demand.

Character		East			Middle			West		
		Range	Mean	SD	Range	Mean	SD	Range	Mean	SD
Physical and aggregate properties										
Air temperature (°C)		15.0 – 30.0	23.0	4.1	15.0 – 34.0	22.3	5.3	16.0 – 34.0	23.7	5.4
Water temperature (°C)		15.0 – 31.0	22.6	5.1	14.0 – 31.0	22.2	5.5	15.0 – 32.0	23.0	5.3
Transparency (cm)		10.0 – 80.0	26.3	9.4	15.0 – 55.0	31.3	9.3	15.0 – 65.0	41.4	10.4
Depth (cm)		42.0 – 240.0	108.9	49.5	75.0 – 160.0	117.5	20.1	70.0 – 180.0	128.9	27.0
EC (mS cm^{-1})		1.4 – 25.1	8.4	5.6	1.9 – 5.1	3.1	0.6	1.0 – 4.3	2.4	1.0
Chlorosity (g l^{-1})		0.5 – 9.6	3.1	2.1	0.5 – 1.8	1.0	0.3	0.3 – 1.6	0.7	0.4
pH		7.3 – 9.8	8.7	0.6	7.6 – 10.0	8.7	0.5	7.8 – 9.6	8.5	0.5
Alkalinity (g l^{-1})		32.0 – 370.0	266.9	49.1	140.0 – 380.0	274.4	52.7	95.0 – 280.0	208.9	34.3
Oxygen properties										
DO	**mg l^{-1}**	3.2 – 12.2	8.1	2.0	5.9 – 18.3	9.1	2.3	4.1 – 15.8	9.0	2.8
COD	**mg l^{-1}**	0.4 – 8.9	4.7	1.7	1.2 – 9.1	4.3	1.7	0.4 – 9.6	4.7	1.8
BOD	**mg l^{-1}**	0.2 – 8.1	3.7	1.5	0.3 – 9.3	3.2	1.7	0.1 – 8.6	4.0	1.7
Dissolved salts										
PO_4	**µg-at. l^{-1}**	0.1 – 4.8	1.6	1.1	0.1 – 9.3	1.0	1.2	0.1 – 3.8	1.1	0.8
NO_3	**µg-at. l^{-1}**	0.1 – 13.5	3.2	2.7	0.0 – 6.5	2.0	1.4	0.7 – 9.5	3.2	2.0
NO_2	**µg-at. l^{-1}**	0.0 – 3.9	1.0	0.8	0.0 – 4.0	0.9	0.7	0.4 – 3.6	1.4	0.8
SiO_3	**µg-at. l^{-1}**	6.3 – 106.3	36.9	26.8	14.8 – 84.2	43.1	21.5	20.8 – 99.7	50.3	24.9
Heavy metals										
Cu	**µg-at. l^{-1}**	1.4 – 23.2	7.2	4.1	0.4 – 16.5	3.8	3.1	1.6 – 17.0	6.3	3.5
Fe	**µg-at. l^{-1}**	0.2 – 33.0	8.7	7.6	0.2 – 12.5	3.1	2.9	0.8 – 14.4	5.7	3.9
Cd	**µg-at. l^{-1}**	0.6 – 13.8	5.5	3.5	0.1 – 9.9	2.2	1.9	0.3 – 5.4	2.4	1.7
Pb	**µg-at. l^{-1}**	0.4 – 13.9	4.4	3.5	0.1 – 9.6	1.9	2.0	0.9 – 12.5	4.3	3.0
Zn		2.9 – 28.8	12.1	6.1	1.9 – 12.3	5.7	2.7	1.1 – 12.1	4.9	3.1

Table 2.3. **Annual range, mean and standard deviation (SD) of water properties along north-south axis in Lake Burullus in 2001, DO: dissolved oxygen, COD: chemical oxygen demand, BOD: biological oxygen demand.**

Character		North			Middle			South		
		Range	Mean	SD	Range	Mean	SD	Range	Mean	SD
Physical and aggregate properties										
Air temperature (°C)		15.0 – 34.0	23.0	5.1	15.0 – 34.0	22.5	4.7	16.0 – 34.0	23.1	4.7
Water temperature (°C)		14.0 – 31.0	22.4	5.4	15.0 – 31.0	22.6	5.4	15.0 – 31.0	22.6	5.1
Transparency (cm)		15.0 – 65.0	39.7	10.1	15.0 – 80.0	29.0	10.6	10.0 – 40.0	25.1	6.8
Depth (cm)		65.0 – 180.0	127.8	26.8	42.0 – 140.0	97.3	21.7	42.0 – 240.0	118.1	49.4
EC (mS cm^{-1})		1.5 – 25.1	5.7	5.9	1.9 – 22.7	6.8	5.7	1.0 – 8.9	4.2	1.9
Chlorosity (g l^{-1})		0.3 – 9.6	2.0	2.4	0.6 – 8.1	2.3	2.0	0.3 – 4.1	1.5	0.8
pH		7.3 – 10.0	8.7	0.6	7.4 – 9.6	8.7	0.6	7.5 – 9.7	8.6	0.5
Alkalinity (g l^{-1})		95.0 – 350.0	240.0	46.6	32.0 – 370.0	258.2	63.3	175.0 – 380.0	272.4	48.1
Oxygen properties										
DO	**mg l^{-1}**	6.1 – 15.8	9.5	2.2	4.7 – 18.3	8.5	2.4	3.2 – 13.9	8.0	2.2
COD		0.4 – 9.1	4.5	1.8	1.4 – 8.9	4.2	1.7	1.2 – 9.6	5.0	1.6
BOD		0.1 – 7.9	3.4	1.6	0.6 – 8.1	3.3	1.6	0.9 – 9.3	4.0	1.6
Dissolved salts										
PO_4	**µg-at. l^{-1}**	0.1 – 9.3	0.8	1.2	0.2 – 3.1	1.0	0.7	0.4 – 4.8	1.9	1.1
NO_3		0.0 – 9.5	1.8	1.6	0.1 – 4.6	1.9	1.3	0.7 – 13.5	4.3	2.5
NO_2		0.0 – 3.5	0.9	0.7	0.0 – 2.1	0.7	0.5	0.2 – 4.0	1.4	0.9
SiO_3		6.3 – 91.7	45.6	23.9	7.2 – 106.3	40.0	27.0	8.7 – 99.7	39.5	24.9
Heavy metals										
Cu	**µg-at. l^{-1}**	0.4 – 14.0	4.7	3.1	0.9 – 14.7	5.2	3.5	1.4 – 23.2	7.4	4.4
Fe		0.4 – 24.2	4.6	4.8	0.3 – 18.7	4.7	4.6	0.2 – 33.0	8.6	7.4
Cd		0.1 – 13.8	3.1	3.3	0.4 – 11.7	3.7	2.9	0.3 – 13.2	4.4	3.2
Pb		0.1 – 11.8	2.5	2.4	0.4 – 13.9	3.1	3.0	0.4 – 13.2	4.8	3.4
Zn		1.1 – 26.4	7.1	5.8	1.9 – 20.1	8.8	5.4	1.2 – 28.8	9.4	5.7

The PCA ordination of the 15 stations based on their water properties indicates a clear separation between the stations of the eastern, middle and western sectors (Fig. 2.2). Although there is a heterogeneity between the stations of each sector, some stations are very similar to each other (e.g. stations 2 and 3 in the eastern sector, and stations 10 and 12 in the middle sector).

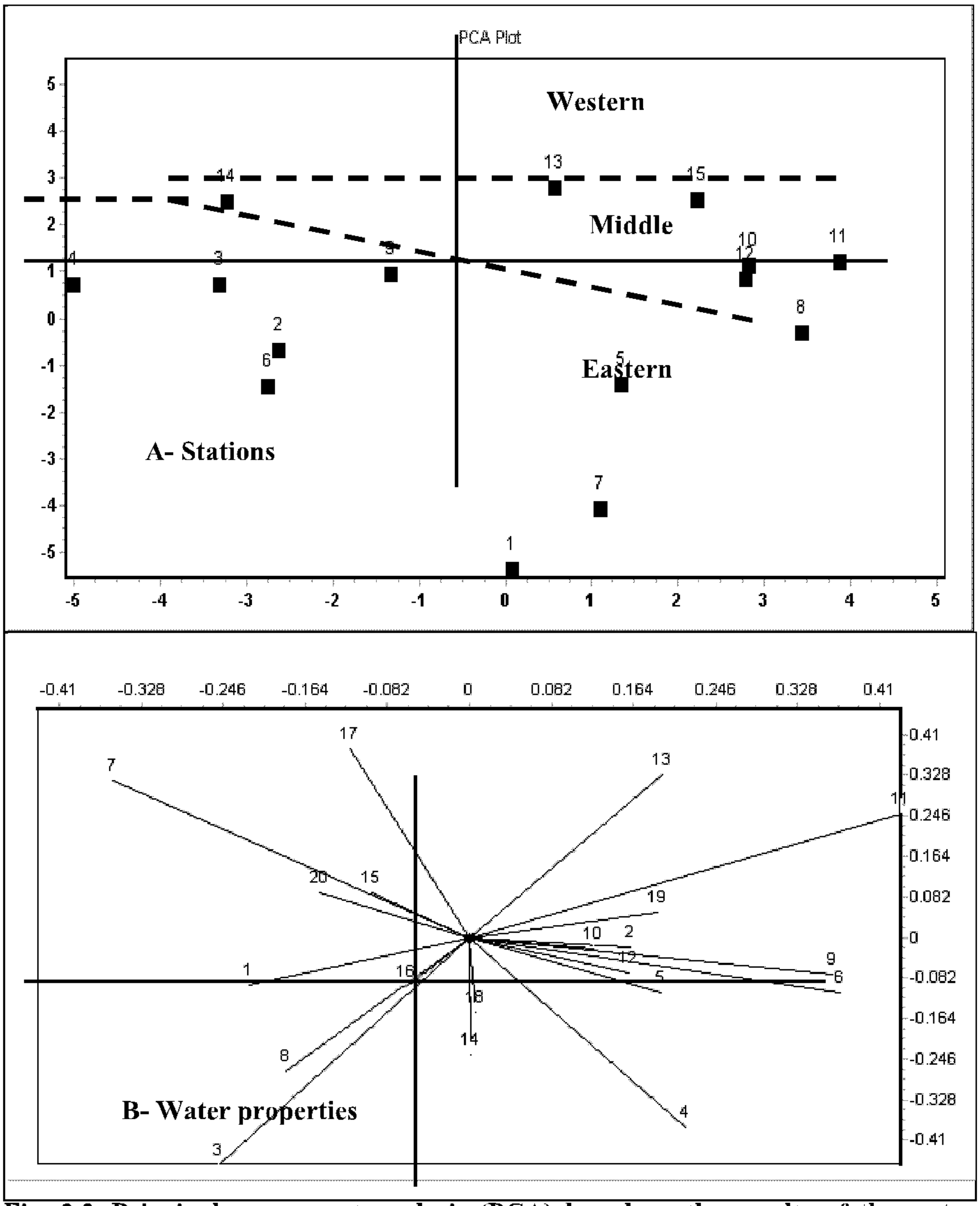


Fig. 2.2. **Principal component analysis (PCA) based on the results of the water properties of the 15 sampled stations in Lake Burullus. The water properties are: 1: air temperature, 2: water temperature, 3: transparency, 4: depth, 5: EC, 6: pH, 7: chlorosity, 8: alkalinity, 9: dissolved oxygen, 10: chemical oxygen demand, 11: biological oxygen demand, 12: phosphate, 13: nitrate, 14: nitrite, 15: silicate, 16: Copper, 17: Iron, 18: Cadmium, 19: Lead and 20: Zinc.**

2.1. PHYSICAL AND AGGREGATE PROPERTIES

Distinguished from the concentrations of the chemical and biological components, this part deals with the physical properties of the water of Lake Burullus at a monthly interval (Jan – Dec. 2001) (Radwan 2004). The estimated properties include temperature, transparency (i.e. turbidity), water depth, electric conductivity (as a measure of salinity), pH (as a measure of acidity), chlorides (as a measure of chlorosity) and $CaCO_3$ (as a measure of alkalinity). The monthly variations in these properties in the water of Lake Burullus is indicated in Fig. 2.3.

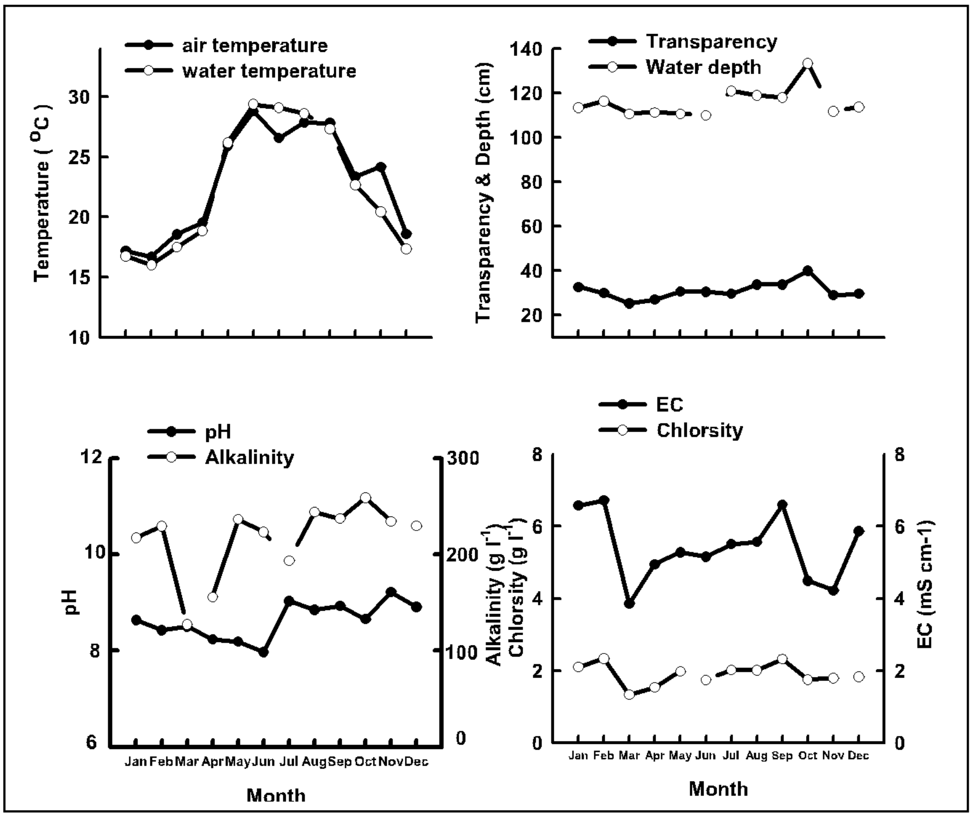


Fig. 2.3. **Monthly variation in the physical and aggregate properties of the water in Lake Burullus.**

2.1.1. Air Temperature

The annual mean of air temperature was 22.9 ± 4.8 °C, with a minimum value of 21.3 °C at station 8 (middle sector) and a maximum of 24.2 °C at station 13 (western sector). Regarding the variation from the eastern to the western sectors of the lake, the mean annual air temperature was 23 °C at the east, 22.3 °C at the middle and 23.7 °C at the west. On the other hand, the air

temperature was slightly lower at the north (22.4 °C) than the south (23.0 °C). The monthly mean air temperature ranged between a minimum of 16.7 °C during February and a maximum of 28.8 °C during June.

2.1.2. Water Temperature

The annual mean of surface water temperature was 22.3 ± 5.2 °C, with a minimum value of 21.8 °C at station 11 (middle sector) and a maximum of 23.3 °C at station 14 (western sector). Regarding the variation from the eastern to the western sectors of the lake, the annual mean was 22.9 °C at the east, 22.2 °C at the middle and 23.0 °C at the west. On the other hand, the annual mean was 22.4 °C at the north and 22.6 °C at the south. The monthly surface water temperature ranged between a minimum of 16.0 °C during February and a maximum of 29.4 °C during June.

2.1.3. Water Transparency

In general, the transparency of the lake water is affected by inflowing water from sea outlet (Boughaz El-Burullus) and drains, wind action, and suspended matters (Beltagy 1985). The annual mean of water transparency was 31.0 ± 11.1 cm, with a minimum value of 22.3 cm at station 4 (eastern sector) and a maximum of 49.6 cm at station 15 (western sector). Regarding the variation from the eastern to the western sectors of the lake, the annual mean was 26.3 cm at the east (the most turbid), 31.3 cm at the middle and 41.4 cm at the west (the clearest). On the other hand, the transparency decreased from north (39.7 cm) to south (25.1 cm). The monthly mean ranged between a minimum of 25.3 cm during March and a maximum of 40.0 cm during October.

2.1.4. Water Depth

The water depth in Lake Burullus is subjected to large variation from day to day. The water level is affected by both amount of drainage water and the exchange water with the Mediterranean Sea through the outlet depending on the wind direction (Beltagy 1985). Generally, the depth increases from east to west and from south to north. The annual mean of water depth was 115.8 ± 38.3 cm with a minimum of 80.8 cm at station 5 in the eastern sector and a maximum of 195.3 cm at station 3 in the same sector. Regarding the variation from the eastern to the western sectors of the lake, the annual mean increased from the east (108.9 cm) to the west (128.9 cm). On the other hand, the mean was 127.8 cm at the north, 97.3 cm at the middle and 118.1 cm at the south. The lowest monthly average of water depth was recorded during June (110 cm), while the highest was during October (133.3 cm).

2.1.5. Salinity

The salinity distribution in the water of Lake Burullus, as noted in electrical conductivity measurements, is heterogeneous. This depends on the water drained by the drains and the water of Berembal Canal, the water invading the lake from the sea (Boughaz El-Burullus) and the degree of mixing. The annual mean of water salinity was 5.4 ± 4.8 mS cm^{-1}, with a minimum of 1.6 mS cm^{-1} at station 14 in the western section and a maximum of 16.8 mS cm^{-1} at station 1 in the eastern sector (the nearest to the sea outlet). Regarding the variation from the eastern to the western sectors of the lake, the annual mean decreased from the east (8.4 mS cm^{-1}) to the west (2.4 mS cm^{-1}), and from the north (5.7 mS cm^{-1}) to the south (4.2 mS cm^{-1}). The salinity decreased during March (3.9 mS cm^{-1}), and increased during January and February (6.6 and 6.7 mS cm^{-1}, respectively). The sea water inflows to the lake during this period (Radwan *et al.* 1997, El-Shinnawy 2002).

2.1.6. Chlorosity

The chlorosity increases with the increase of salinity (Fig. 2.2). The annual mean of chlorosity was 1.9 ± 1.8 g l^{-1}, with a minimum of 0.6 g l^{-1} at stations 14 and 15 (western sector) and a maximum of 6.6 g l^{-1} at station 1 (eastern sector). Regarding the variation from the east to the west, the annual mean was the highest at the eastern sector (3.1 g l^{-1}), and the lowest at the western sector (0.7 g l^{-1}). On the other hand, the chlorosity was slightly higher at the north (2.0 g l^{-1}) than the south (1.5 g l^{-1}). Temporally, chlorosity had the same trend of salinity where it decreased during March (1.3 g l^{-1}), and increased in January and February having 2.1 and 2.3 g l^{-1}, respectively (Radwan *et al.* 1997, El-Shinnawy 2002).

2.1.7. pH

Water in Lake Burullus is alkaline throughout the year. The annual mean of pH was 8.6 ± 0.6, with a minimum of 8.4 at station 14 (western sector) and a maximum of 8.9 at station 7 (middle sector). The variation from the eastern to the western sectors of the lake indicated an annual mean of 8.7 at the eastern and middle sectors and 8.5 at the western sector. On the other hand, pH was 8.7 at the north and 8.6 at the south. The monthly annual mean ranged between 8.0 during June and 9.2 during November.

2.1.8. Alkalinity

The annual mean of alkalinity was 257.8 ± 53.7 g l^{-1}, with a minimum of 188.0 g l^{-1} at station 15 in the western sector and a maximum of 309.6 g l^{-1} at station 9 in the middle sector. Regarding the variation along the east-west axis, the middle sector had the highest alkalinity (274.4 g l^{-1}), followed by the eastern (266.9 g l^{-1}), while the western sector had the lowest one (208.9 g l^{-1}). On the

other hand, the annual mean of alkalinity increased from the north to the south (240.0 g l^{-1} at the north, 258.2 g l^{-1} at the middle and 272.4 g l^{-1} at south of the lake). This variable increased during August (272.0 g l^{-1}) and October (279.6 g l^{-1}) and decreased during March (213.7 g l^{-1}).

2.2. OXYGEN PROPERTIES

These properties include dissolved oxygen (DO), chemical oxygen demand (COD) and biological oxygen demand (BOD). DO levels in natural and waste waters depend on the physical, chemical and biochemical activities. The analysis of DO is a key test in water pollution and waste treatment process control (Greenberg *et al.* 1992). On the other hand, BOD is an empirical test used to determine the relative oxygen requirements needed for the biochemical degradation and oxidation of organic and inorganic materials. COD is a measure of the oxygen equivalent of the organic matter content of a water sample that is susceptible to oxidation by a strong chemical oxidant. For water samples from a specific source, COD can be related empirically to BOD, organic carbon or organic matter (Greenberg *et al.* 1992). The variations in these properties are indicated in Fig. 2.4.

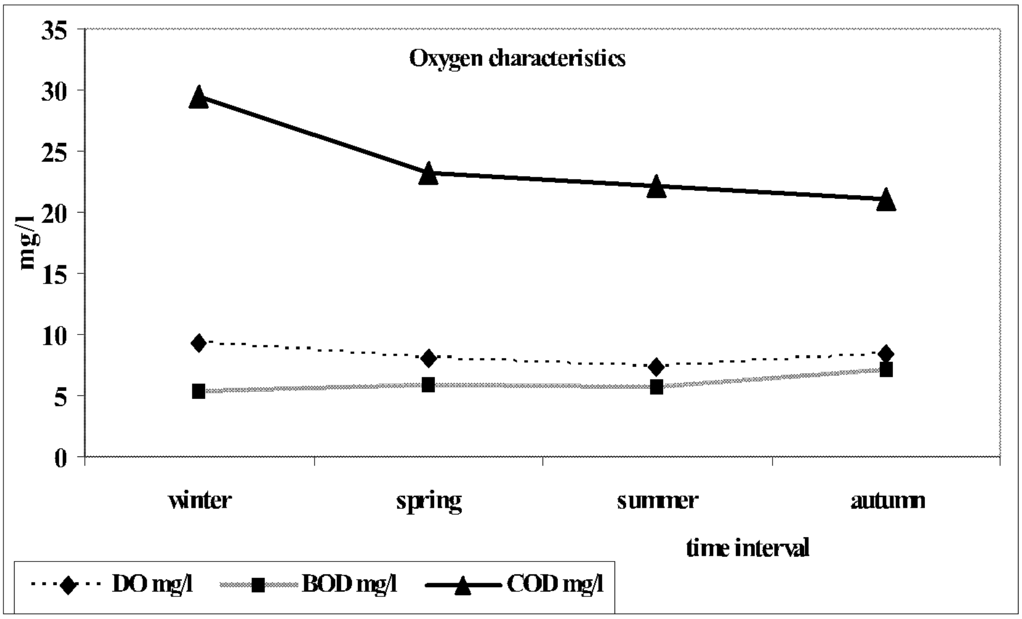


Fig.2.4. **Seasonal variation of oxygen properties (dissolved oxygen, biological oxygen demand and chemical oxygen demand) in Lake Burullus during 2004** (Ali 2004)

2.2.1. Dissolved Oxygen (DO)

The annual mean of dissolved oxygen in Lake Burullus was 8.2 mg l^{-1} (Ali 2004), with a minimum of 6.6 mg l^{-1} at eastern sector and a maximum of 10.4 mg l^{-1} at western sector. Regarding the variation from the eastern to the western sectors of the lake, the maximum dissolved oxygen was observed in the middle and western sectors, while the minimum was recorded in the eastern sector. On the other hand, the dissolved oxygen decreased from north (9.5 mg l^{-1}) to south (8.0 mg l^{-1}). This trend may be related to the oxidation - reduction processes, as well as photosynthetic activities, which in turn correlated with the load of organic matters discharged into the lake through the drains (Radwan 2004). The seasonal mean of dissolved oxygen varied between 11.2 mg l^{-1} in winter and 6.6 mg l^{-1} in summer.

2.2.2. Chemical Oxygen Demand (COD)

The annual mean of chemical oxygen demand was 23.95 mg l^{-1} during 2004 (Ali 2004),with a minimum of 16.0 mg l^{-1} at the eastern sector and a maximum of 36.0 mg l^{-1} at the western sector. COD was slightly higher in the eastern and western sectors than the middle one. On the other hand, COD was lower at the north than the south. It had the highest value during winter (36 mg l^{-1}) and the lowest during spring (16.0 mg l^{-1}).

2.2.3. Biological Oxygen Demand (BOD)

The annual mean of biological oxygen demand was 6.0 mg l^{-1} during 2004 (Ali 2004), with a minimum of 3.5 mg l^{-1} at the west sector and a maximum of 8.28 mg l^{-1} at the middle sector. Regarding the variation along the east-west axis, BOD was similar to the chemical oxygen demand, where it was higher in the eastern and western sectors than the middle one. On the other hand, it was lower in the north than the south. Comparable to COD, BOD had a maximum value during autumn (8.28 mg l^{-1}) and a minimum during winter (3.5 mg l^{-1}).

2.3. DISSOLVED SALTS

The contents of dissolved salts in the water of Lake Burullus have the following sequence: $SiO_2 > NO_3 > PO_4 > NO_2$. The presence of silicate may be due to the nature of the sandy bottom sediments of the lake, while the presence of nitrite, nitrate and phosphate is due to the drainage of fertilizers from the agricultural land into the lake. In general, the nutrient concentrations in Lake Burullus are related to the input of all domestic, industrial and mainly agricultural wastes from the reclaimed lands surrounding the lake (Radwan 2001). The variations in these properties are indicated in Fig. 2.5.

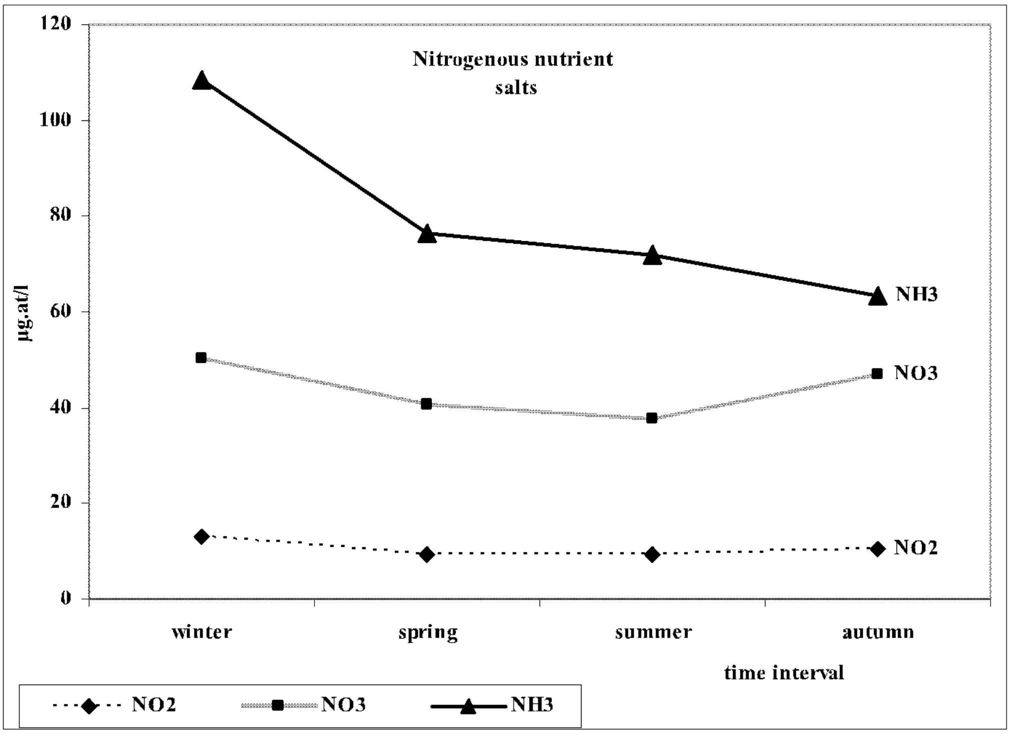


Fig.2.5. **Seasonal variation of nitrogenous nutrient salts (nitrite, nitrate and ammonia µg.at/l) in Lake Burullus during 2004 (Ali 2004)**

2.3.1. Phosphate (PO_4)

The annual mean of phosphate content during 2001 in Lake Burullus was 1.2 ± 1.1 µg-at. l^{-1}, with a minimum of 0.6 µg-at. l^{-1} at stations 1 (eastern sector), 8 and 11 (middle sector); and a maximum of 2.7 µg-at. l^{-1} at station 4 in the eastern sector (Radwan 2001). The mean of phosphate content was higher in the eastern sector of the lake (1.6 µg-at. l^{-1}) than in the middle and western ones (1.0 and 1.1 µg-at. l^{-1}, respectively). On the other hand, the monthly fluctuation indicated a minimum value during January (0.6 µg-at. l^{-1}) and a maximum during March (1.8 µg-at. l^{-1}). Ali (2004) recorded higher values during 2004, with a maximum value during autumn (18 µg-at. l^{-1}) and a minimum during spring (1.2 µg-at. l^{-1}).

2.3.2. Nitrate (NO_3)

The annual mean of nitrate in the water of Lake Burullus was 2.8 ± 2.3 µg-at. l^{-1} during 2001, with a minimum of 0.8 µg-at. l^{-1} at stations 1 and 7 (eastern sector) and a maximum of 6.5 µg-at. l^{-1} at station 4 in the same sector. The mean value of nitrate content in the eastern and western sectors of the lake (3.2 µg-at. l^{-1}) was higher than that of the middle sector

(2.0 μg-at. l^{-1}). On the other hand, Ali (2004) recorded high values during 2004, with an average maximum value of 50.2 μg-at. l^{-1} in winter and a minimum in summer (37.6 μg-at. l^{-1}). The maximum value of NO_3 was 135.0 μg-at. l^{-1}in the eastern sector in front of the drains (Fig. 2.5).

2.3.3. Nitrite (NO_2)

The annual mean value of nitrite in Lake Burullus was 1.1 ± 0.8 μg-at. l^{-1} during 2001, with a minimum of 0.3 μg-at. l^{-1} at station 1 (eastern sector) and a maximum of 2.0 μg-at. l^{-1} at station 4 in the same sector (Radwan 2001). On the other hand, the nitrite increased in the north (0.9 μg-at. l^{-1}) than the south (1.4 μg-at. l^{-1}). The monthly mean had a minimum value during April (0.7 μg-at. l^{-1}) and a maximum during February (1.4 μg-at. l^{-1}). Ali (2004) recorded higher values during 2004, with a maximum value of 41.9 μg-at. l^{-1} in the estern sector during winter and a minimum of 0.9 μg-at. l^{-1} in Boughaze area (Fig. 2.5).

2.3.4. Silicate (SiO_2)

The annual mean of silicate in Lake Burullus was 41.7 ± 25.1 μg-at. l^{-1}, with a minimum of 29.8 μg-at. l^{-1} at station 5 (eastern sector) and a maximum of 51.9 μg-at. l^{-1} at station 15 in the western sector. It increased from the east (36.9 μg-at. l^{-1}) to west (50.3 μg-at. l^{-1}), and decreased from the north (45.6 μg-at. l^{-1}) to south (39.5 μg-at. l^{-1}). On the other hand, the minimum value was obtained (19.5 μg-at. l^{-1}) during July, while the maximum (81.9 μg-at. l^{-1}) was during April.

2.4. HEAVY METALS

The content of heavy metals in the water of lake Burullus had the following sequence: Zn > Fe > Cu > Cd > Pb. Generally, most of the estimated heavy metals of the water near to the southern shore of the lake were higher than those near the northern one. This trend could be attributed to the effect of sewage effluents from the drains at the south particularly at the stations near to the mouths of drains with increasing levels of organic matter and the clay nature of the sediments. In addition, the trend of variation along east-west axis is as follows: eastern sector > western sector > middle sector for all the estimated heavy metals except Zn (east > middle > west). On the other hand, the period from February to May had the peak of heavy metals increase, while the period from June to September was characterized by a remarkable decrease in heavy metals (Fig. 2.6).

2.4.1. Copper (Cu)

The annual mean of copper was 5.9 ± 4.0 μg-at. l^{-1}, with a minimum of 2.6 μg-at. l^{-1} at station 12 (middle sector) and a maximum of 8.8 μg-at. l^{-1} at station 3 in the eastern sector. Regarding the variation from the eastern to the

western sectors of the lake, the mean values were 7.2 µg-at. l^{-1} at the east, 3.8 µg-at. l^{-1} at the middle and 6.3 µg-at. l^{-1} at the west. On the other hand, the copper increased from the north (4.7 µg-at. l^{-1}) to the south (7.4 µg-at. l^{-1}). The monthly mean of copper ranged between 3.6 µg-at. l^{-1} during June and August and 11.5 µg-at. l^{-1} during May.

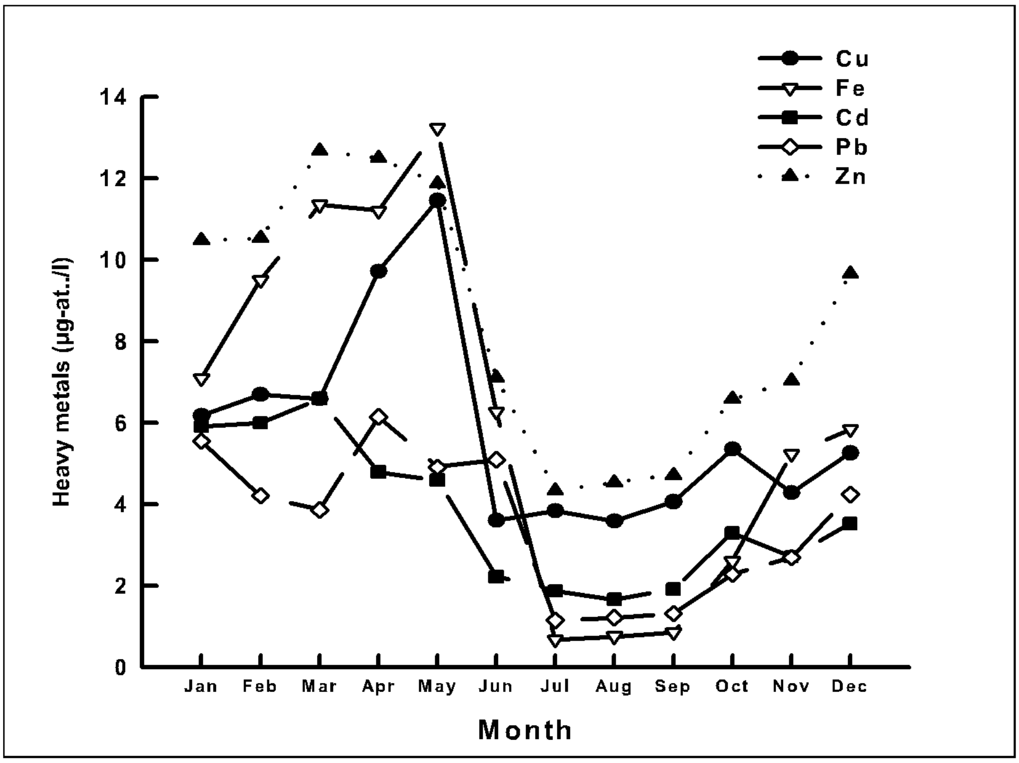


Fig. 2.6. **Monthly variation in the heavy metals in the water of Lake Burullus during 2001.**

2.4.2. Iron (Fe)

The annual mean of iron was 6.2 ± 6.2 µg-at. l^{-1}, with a minimum of 1.9 µg-at. l^{-1} at station 11 (middle sector) and a maximum of 13.7 µg-at. l^{-1} at station 4 in the eastern sector. Regarding the variation from the east to the west, the mean values were 8.7 µg-at. l^{-1} in the east, 3.1 µg-at. l^{-1} in the middle and 5.7 µg-at. l^{-1} in the west. On the other hand, the iron, similar to the other heavy metals, increased from the north (4.6 µg-at. l^{-1}) to the south (8.6 µg-at. l^{-1}). The monthly mean of iron ranged between 0.7 µg-at. l^{-1} during June and 13.2 µg-at. l^{-1} during May.

2.4.3. Cadmium (Cd)

The annual mean of cadmium was 3.8 ± 3.2 µg-at. l^{-1}, with a minimum of 1.6 µg-at. l^{-1} at station 10 (middle sector) and a maximum of 8.4 µg-at. l^{-1} at

station in the eastern sector. Regarding the variation from the east to the west, the mean value in the east (5.5 μg-at. l^{-1}) was higher than that of the middle (2.2 μg-at. l^{-1}) and west (2.4 μg-at. l^{-1}). On the other hand, the cadmium, similar to the other heavy metals, increased from the north (3.1 μg-at. l^{-1}) to the south (4.4 μg-at. l^{-1}). The monthly mean ranged between 1.7 μg-at. l^{-1} during August and 6.6 μg-at. l^{-1} during March.

2.4.4. Lead (Pb)

The lead had the lowest value of all the estimated heavy metals in Lake Burullus, with an annual mean of 3.6 ± 3.2 μg-at. l^{-1} (it approximates the annual mean of cadmium). It had a minimum value of 1.1 μg-at. l^{-1} at station 11 (middle sector) and a maximum of 6.3 μg-at. l^{-1} at station 14 in the western sector. Regarding the variation along the east-west axis, the mean value in the east was 4.4 μg-at. l^{-1}, that of the middle was 1.9 μg-at. l^{-1} and that of the west was 4.3 μg-at. l^{-1}. On the other hand, the lead increased from the north (2.5 μg-at. l^{-1}) to the south (4.8 μg-at. l^{-1}). The monthly mean ranged between 1.2 μg-at. l^{-1} during July and 6.2 μg-at. l^{-1} during April.

2.4.5. Zinc (Zn)

Zinc has the highest values of heavy metals in Lake Burullus, with an annual mean of 8.5 ± 5.7 μg-at. l^{-1}. It had a minimum of 3.5 μg-at. l^{-1} at station 15 (western sector) and a maximum of 17.2 μg-at. l^{-1} at station 1 in the eastern sector. Regarding the variation along the east-west axis, the mean value decreased from 12.1 μg-at. l^{-1} in the east to 4.9 μg-at. l^{-1} in the west. On the other hand, it increased from the north (7.1 μg-at. l^{-1}) to the south (9.4 μg-at. l^{-1}). The monthly mean ranged between 4.3 μg-at. l^{-1} during July and 12.7 μg-at. l^{-1} during March.

2.5. CHANGES IN WATER CHEMISTRY

The comparison of the dissolved salts in the water of Lake Burullus in 2001 (Radwan 2001 & 2004) with that of 1987 (Abdel-Moati *et al.* 1988) and 1997 (Radwan *et al.* 1997) indicated an increase of nitrate, nitrite and phosphate from 1987 to 1997, but a decrease in 2001 (Table 2.4). On the other hand, silicate had a decreasing pattern from 66.8 μg-at. l^{-1} in 1987 to 47.3 μg-at. l^{-1} in 1997 and 41.7 μg-at. l^{-1} in 2001. Regarding the variation of heavy metals, there is a continuous increase in Cu, Zn, Pb and Cd contents from 1987 (Abdel Moneim *et al.* 1990) to 1997 (Radwan 1997) and then to 2001 (Radwan 2001 & 2004).

Table 2.4. **Changes in water chemistry in Lake Burullus.**

a- Dissolved salts (µg-at. l^{-1})					
Year	**NO_3**	**NO_2**	**PO_4**	**SiO_3**	**Reference**
1987	4.0	0.8	1.6	66.8	Abdel-Moati *et al.* (1988)
1997	5.7	2.1	2.9	47.3	Radwan *et al.* (1997)
2001	2.8	1.1	1.3	41.7	Radwan 2001 & 2004
2004	43.8	10.5	9.05	112.2	Ali 2004
b- Heavy metals (µg-at. l^{-1})					
Year	**Cu**	**Zn**	**Pb**	**Cd**	**Reference**
1987	2.3	5.5	1.9	1.6	Abdel-Moneim *et al.* (1990)
1997	3.5	6.8	2.7	1.9	Radwan (1997)
2001	5.9	8.5	3.6	3.8	Radwan 2001 & 2004

2.6.CORRELATION BETWEEN WATER PROPERTIES

The simple linear correlation analysis of the water properties in Lake Burullus (Table 2.5) indicates that the salinity and chlorosity are positively correlated with each other ($r = 0.99$, $P < 0.001$). In addition, Cd and Zn are positively correlated with each other on one hand ($r = 0.94$, $P < 0.001$), and with the salinity and chlorosity on the other hand ($r = 0.84 – 0.86$, $P < 0.001$). These correlations indicate that a considerable portion of the Cd and Zn in the water of Lake Burullus is due to the sea water (the main source for increasing water salinity in this lake). The pollution by detergents that come mainly from the sea may partially interpret the increase of Zn. No doubt, that the drains which carry the liquid industrial wastes are among the main sources for heavy metal pollution in Lake Burullus (Mahmoud & Beltagy 1988).

Phosphates, nitrates and nitrites, that are used as fertilizers for the agricultural land in the catchment area of Lake Burullus, are positively correlated with each other (they are washed with the agricultural drainage into the lake). In addition Cu, Fe and Pb are positively correlated with each other on one hand, and with the previously mentioned dissolved salts on the other hand. This may indicate that the main source for pollution with these heavy metals are the agricultural drainage. This conclusion is supported by the fact that the levels of these heavy metals are much higher in the south (where all the drains pour their drainage water into the lake) than the north.

Table 2.5. **Matrix of Pearson simple linear correlation coefficients (r) between the water properties of Lake Burullus during 2001. *: P < 0.05, **: P < 0.01, ***: P < 0.001.**

Water	Physical and aggregate properties				Oxygen properties			Dissolved salts				Heavy metals				
properties	EC	Cl	pH	Alk.	DO	COD	BOD	PO_4	NO_3	NO_2	SiO_2	Cu	Fe	Cd	Pb	Zn
Physical and aggregate properties																
Transparency	-0.15	0.16	0.06	-0.68**	0.58*	-0.33	-0.28	-0.66**	-0.45	-0.21	0.73**	-0.39	-0.50	-0.42	-0.37	-0.46
EC	---	0.99***	0.46	0.03	0.00	-0.08	-0.13	-0.20	-0.36	-0.56*	-0.38	0.26	0.38	0.84***	0.10	0.84**
Cl		---	0.41	0.04	-0.02	-0.07	-0.12	-0.18	-0.33	-0.53*	-0.40	0.28	0.42	0.85***	0.13	0.86***
pH			---	0.00	0.34	-0.17	-0.43	-0.48	-0.65**	-0.74**	-0.32	-0.35	-0.30	0.24	-0.54*	0.22
Alk.				---	-0.06	0.05	-0.02	0.33	0.23	0.12	-0.48	0.01	0.15	0.13	-0.07	0.23
Oxygen properties																
DO					---	-0.20	-0.24	-0.69**	-0.55*	-0.37	0.39	-0.51	-0.60*	-0.32	-0.60*	-0.38
COD						---	0.72**	0.54*	0.37	0.35	-0.10	0.50	0.31	0.21	0.48	0.16
BOD							---	0.63*	0.63*	0.63*	0.08	0.75***	0.50	0.23	0.80***	0.16
Dissolved salts																
PO_4								---	0.88***	0.78***	-0.20	0.73**	0.72**	0.26	0.77***	0.23
NO_3									---	0.93***	-0.04	0.67**	0.71**	0.08	0.76***	0.06
NO_2										---	0.22	0.53*	0.51	-0.14	0.66**	-0.20
SiO_3											---	-0.08	-0.30	-0.41	0.00	-0.55*
Heavy metals																
Cu												---	0.86***	0.63*	0.95***	0.60*
Fe													---	0.71**	0.84***	0.68**
Cg														---	0.48	0.94***
Pb															---	0.44
Zn																---

2.7. SUMMARY

Water properties of Lake Burullus were evaluated during 2001 and 2004 in 15 stations representing the eastern, middle and western sectors of the lake. The estimated variables were classified into 4 main groups: physical and aggregate properties (air temperature, water temperature, transparency, depth, salinity, chlorosity, acidity and alkalinity), oxygen properties (dissolved oxygen, chemical and biological oxygen demands), dissolved salts (phosphate, nitrate, nitrite and silicate) and heavy metals (cupper, iron, cadmium, lead and zinc). The PCA ordination of the 15 stations based on their water properties indicates a clear separation between the stations of the eastern, middle and western sectors.

The annual mean of air and water temperatures were 22.9 and 22.3 °C, with spatial ranges among stations of 21.3-24.2 and 21.8-23.3 °C, and monthly ranges of 16.7-28.8 and 16.0- 29.4 °C. The annual means of water transparency and water depth were 31.0 and 115.8 cm, with spatial ranges of 22.3-49.6 and 80.8-195.3 cm, and monthly ranges of 25.3-40.0 and 110-133.3 cm. The annual mean of water salinity was 5.4 mS cm^{-1}, with spatial range of 1.6-16.8 mS cm^{-1}, and monthly range of 3.9-6.7 mS cm^{-1}. Chlorosity had the same trend of salinity with an annual mean of 1.9 g l^{-1}, spatial range of 0.6-6.6 g l^{-1} and monthly range of 1.3-2.3 g l^{-1}. Water in Lake Burullus is alkaline throughout the year. The annual mean of pH was 8.6, with a spatial range of 8.4-8.9 and a monthly range 8.0-9.2. On the other hand, the annual mean of alkalinity was 257.8 mg l^{-1}, with a spatial range of 188.0-309.6 mg l^{-1} and monthly range of 213.7-279.6 mg l^{-1}.

The annual mean of dissolved oxygen (DO), chemical (COD) and biological (BOD) oxygen demands were 8.2, 23.95 and 6.0 mg l^{-1}during 2004, respectively. The concentrations of dissolved salts had the following sequence: $SiO_3 > NO_3 > NO_2 > PO_4$, with annual means of 112.2, 43.8, 10.5 and 9.05 µg-at. l^{-1}.

The concentrations of heavy metals had the following sequence: Zn > Fe > Cu > Cd > Pb, with annual means of 8.5, 6.2, 5.9, 3.8 and 3.6 µg-at. l^{-1}. Generally, most of the estimated heavy metals of the water near to the southern shore were higher than those near the northern shore. In addition, the trend of variation along east-west axis was as follows: eastern sector > western sector > middle sector for all metals except Zn (east > middle > west). The spatial ranges in µg-at. l^{-1} were 3.5-17.2 (Zn), 1.9-13.7 (Fe), 2.6-8.8 (Cu), 1.6-8.4 (Cd) and 1.1-6.3 (Pb). On the other hand, the period extended from February to May had the peak of heavy metals increase, while the period from June to September had the reverse. The monthly ranges in µg-at. l^{-1} were 4.3-12.7 (Zn), 0.7-13.2 (Fe), 3.6-11.5 (Cu), 1.7-6.6 (Cd) and 1.2-6.2 (Pb).

The comparison of the dissolved salts in the water of Lake Burullus in 2001 and 2004, with those of 1987 and 1997 indicated an increase of nitrate, nitrite and phosphate from 1987 to 1997, but a decrease in 2001and increase in 2004. On the other hand, silicate had a decreasing pattern from 66.8 µg-at. l^{-1} in 1987 to 47.3 µg-at. l^{-1} in 1997 and 41.7 µg-at. l^{-1} in 2001 then increase in 2004 (112.2 µg-at. l^{-1}). Regarding the heavy metals, there was a continuous increase in Cu, Zn, Pb and Cd contents from 1987 to 1997 and then to 2001. The correlation between salinity and chlorosity was significant positive. In addition, Cd and Zn had significant positive correlation with each other, on one hand, and with the salinity and chlorosity, on the other hand. This trend indicates that a considerable portion of the Cd and Zn in the water of Lake Burullus is due to the sea water (the main source for increasing water salinity in this lake). Phosphate, nitrate and nitrite, that used as fertilizers for the agricultural land in the catchment area of Lake Burullus, were positively correlated with each other (they are washed with the agricultural drainage into the lake). In addition Cu, Fe and Pb had significant positive correlations with each other on one hand, and with the previously mentioned dissolved salts on the other hand. This may indicate that the main source for pollution with these heavy metals are the agricultural drainage.

2.8. REFERENCES

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Chapter 3
Sediment Properties

3.1. NATURE OF BOTTOM SEDIMENTS

The bottom sediments of Lake Burullus are mainly derived from the suspended load of seston (i.e. the total particulate matter suspended in water), clay and silt. These are carried annually into the lake through the drain water, sea water and wind. Farther away from the effect of the drains, broken calcareous shells and sand are mixed with silt and clay constituting the calcareous sand, silt and clay mixture. The bottom along the northern shores, extending from the lake-sea connection westwards, is mainly clayey-sand, silty sand with some patches formed of molluscan shells. The eastern and western regions of the lake are silty clay (Fig. 3.1: after Zazou as quoted by Darrag 1983). The southern shore sediments, which receive directly the drain discharge, is mainly formed of clay and silt with small areas covered with molluscan shells. The bottom sediments of most southern drains is of the same nature as that of the neighbouring agricultural lands and less mixed with broken shells than the lake bottom sediments.

3.2. SEDIMENTATION RATES

Birks *et al.* (2001) reported that, although Lake Burullus is more saline than Manzala and Edku lakes, there have nonetheless been significant reductions in salinity during the 20th century. The macrofossil record indicates an initial shift towards a freshwater environment at about 24 cm, with further significant changes at 16 cm, and 7 cm. The earliest of these features was probably caused by the initial impact of the first effective Nile barrages, and can be dated to the early 20th century. The later change at 16 cm is a little below the onset of the ^{137}Cs record (dated 1954) and is most likely associated with the impact of later barrages constructed during 1933 – 1951. The most recent change is close to the 1963 depth determined from the ^{137}Cs record, and is probably a response to the essential completion of the Aswan High Dam in 1964 (Appleby *et al.* 2001).

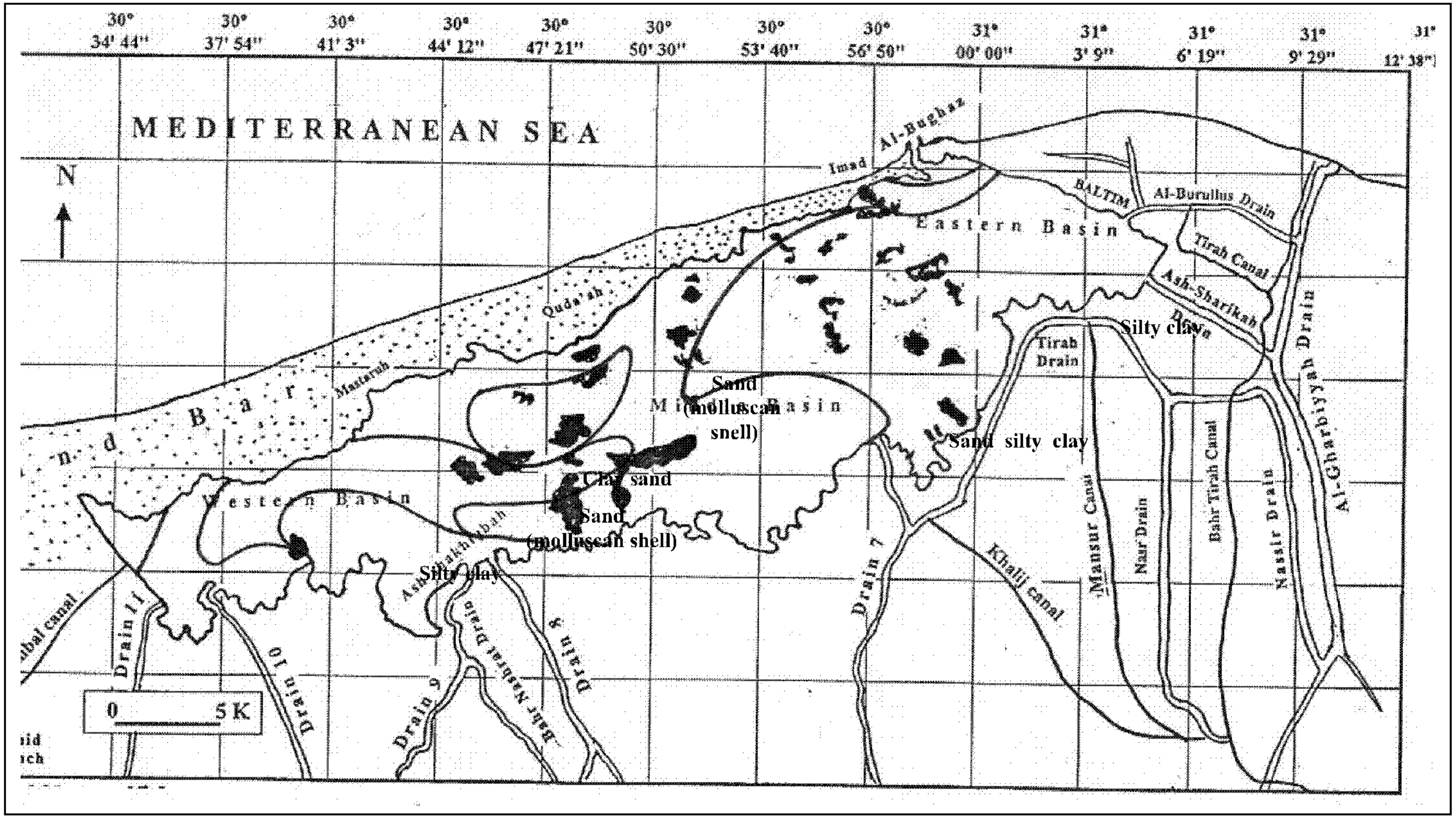

Fig. 3.1. **Bottom nature of Lake Burullus (after Zazou as quoted by Darrag 1983).**

The results of the study of Appleby *et al.* (2001) suggest a significant reduction in sedimentation rates in Lake Burullus after approximately 1960 (Table 3.1). The trend of the pre-1960 biostratigraphic dates suggests that the first significant fresh water changes (ca. 24 cm) can again be dated ca. 1920. The pre-1960 sedimentation rate is calculated to be 0.32 g cm^{-2} yr^{-1} (3.9 mm yr^{-1}), significantly higher than the post-1960 value of 0.075 g cm^{-2} yr^{-1} (2.1 mm yr^{-1}). Sediments in the top 7 cm have a very much lower dry bulk density than those beneath this depth. These results may further indicate reduced minerogenic sediment inputs as a consequence of irrigation - drainage changes, and the end of Nile floods and input of silt following the construction of Aswan High Dam.

Table 3.1. **Chronology and sedimentation rate in Lake Burullus (after Appleby *et al.* 2001).**

Depth	Chronology				Sedimentation rate		
cm	g cm^{-2}	Date	Age (yr)	±	g cm^{-2} yr^{-1}	mm yr^{-1}	± (%)
0	0.00	1998	0	0	-	-	-
1	0.06	1997	1	1	0.077	4.7	20
3	0.49	1992	6	2	0.077	3.2	20
5	1.42	1980	18	5	0.077	3.2	20
7	2.61	1964	34	7	0.077	2.4	20
9	3.80	1958	40	8	0.320	2.4	20
11	5.12	1954	44	9	0.320	2.6	20
13	6.51	1950	48	10	0.320	3.0	20
15	8.11	1945	53	11	0.320	4.2	20
17	9.80	1939	59	12	0.320	3.9	20
19	11.43	1934	64	13	0.320	3.7	20
21	13.25	1929	69	14	0.320	3.6	20
23	15.11	1923	75	15	0.320	3.6	20
25	16.92	1917	81	16	0.320	3.7	20
27	18.63	1912	86	17	0.320	3.8	20
29	20.12	1907	91	18	0.320	3.9	20
31	21.65	1902	96	19	0.320	4.1	20

3.3. SEDIMENT PROPERTIES

The bottom sediments of Lake Burullus were collected from fifteen stations during winter (January) and summer (June) of 2000 and 2001 (El-Shinnawy 2002) (Fig. 2.1). The samples were prepared to carry out the following analysis: EC, Cl, pH and the percentage of organic matter, in addition to the heavy metals: Fe, Cu, Zn, Pb, Cd and Ni (Tables 3.2, 3.3). Comparable to the PCA correlation of the 15 stations, based on the water properties, the PCA ordination of the same stations, based on the sediment properties indicates a clear separation between the stations of the eastern, middle and western sectors of the lake (Fig. 3.2). Although there is a heterogeneity between the stations of each sector, some

Table 3.2. **Annual mean of sediment properties at 15 stations in Lake Burullus. The maximum and minimum values are underlined.**

Variable	Eastern sector							Middle sector					Western sector			Mean±SD
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
EC (mS cm^{-1})	<u>6.4</u>	4.0	2.6	1.7	1.6	1.5	4.2	2.0	1.1	1.0	1.0	1.0	1.1	0.8	<u>0.6</u>	2.0±1.8
Cl (g l^{-1})	<u>2.1</u>	1.1	0.9	0.8	0.8	0.8	1.4	0.6	0.4	0.3	0.4	0.4	0.5	0.3	<u>0.2</u>	0.7±0.6
pH	7.9	<u>7.5</u>	7.6	8.0	8.0	7.9	7.8	8.0	7.7	7.6	8.0	7.8	<u>8.1</u>	7.6	8.0	7.8±0.4
OM (%)	<u>0.8</u>	2.3	2.1	1.9	2.3	3.7	0.9	2.5	3.1	2.7	4.2	2.6	3.2	<u>5.6</u>	3.5	2.8±1.4
Heavy metals (ppm)																
Fe (x 10^3)	<u>35.1</u>	10.5	15.3	13.1	6.5	17.6	8.4	<u>2.7</u>	22.6	12.0	8.6	4.2	27.3	34.9	23.8	16.2±16.6
Cu	12.3	<u>8.9</u>	16.6	<u>47.3</u>	18.6	32.0	19.2	12.5	37.2	16.8	19.4	12.4	26.9	30.1	34.1	22.9±11.3
Zn	23.7	38.3	49.7	<u>119.7</u>	26.1	66.7	38.1	<u>22.2</u>	86.1	69.3	45.0	31.5	86.2	96.7	84.8	58.9±30.2
Pb	9.9	12.0	16.0	<u>54.8</u>	17.3	31.5	15.7	10.8	13.6	<u>8.7</u>	14.4	16.5	16.7	30.1	11.3	18.6±12.0
Cd	1.1	1.3	6.2	1.6	<u>45.9</u>	2.8	1.0	1.2	4.9	2.2	1.2	<u>0.8</u>	4.2	2.2	2.5	5.3±22.7
Ni	<u>3.3</u>	5.9	9.5	30.0	25.3	32.5	7.8	13.9	45.4	63.6	53.8	40.1	<u>72.5</u>	64.7	42.4	34.0±23.1

Table 3.3. **Annual range, mean and standard deviation (SD) of sediment properties along east-west and north-south axes in Lake Burullus. OM: organic matter.**

a- East-west axis	**East**			**Middle**			**West**		
Character	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**
EC (mS cm^{-1})	0.8 – 9.1	3.1	2.2	0.6 – 3.6	1.2	0.6	0.5 – 1.6	0.8	0.3
Cl (gm l^{-1})	0.5 – 3.0	1.1	0.6	0.0 – 1.2	0.4	0.3	0.0 – 0.8	0.3	0.2
pH	7.0 – 8.0	7.8	0.3	7.0 – 9.0	7.8	0.4	7.0 – 9.0	7.9	0.4
OM (%)	0.6 – 4.1	2.0	1.1	1.0 – 5.3	3.0	1.2	2.7 – 6.1	4.1	1.2
Heavy metals (ppm)									
Fe (x 10^3)	0.0 – 73.5	15.2	17.0	0.0 – 32.5	10.0	10.0	0.0 – 51.2	28.7	18.5
Cu	7.3 – 52.7	22.1	12.8	7.9 – 41.9	19.7	9.9	18.3 – 39.8	30.4	5.9
Zn	18.6 – 126.9	51.7	31.8	18.5 – 91.4	50.8	25.0	71.2 – 105.3	89.2	9.7
Pb	7.9 – 63.5	22.4	15.2	5.1 – 19.7	12.8	3.8	7.8 – 32.8	19.4	8.8
Cd	0.6 – 8.3	2.3	1.9	0.4 – 7.3	2.1	1.8	1.9 – 6.2	3.0	1.2
Ni	1.9 – 37.4	16.3	12.1	11.1 – 67.9	43.4	17.9	30.6 – 88.9	59.8	16.4
b- North-south axis	**North**			**Middle**			**South**		
EC (mS)	0.5 – 9.1	2.0	2.5	0.6 – 6.2	2.8	1.9	0.7 – 3.3	1.5	0.7
Cl (gm l^{-1})	0.1 – 3.0	0.7	0.8	0.0 – 2.1	0.8	0.6	0.0 – 1.3	0.7	0.3
pH	7.0 – 9.0	7.9	0.3	7.0 – 8.0	7.7	0.3	7.0 – 9.0	7.8	0.4
OM (%)	0.6 – 5.3	2.9	1.5	0.7 – 3.8	2.1	1.0	0.9 – 6.1	3.1	1.5
Heavy metals (ppm)									
Fe (x 10^3)	0.0 – 73.5	19.8	21.7	0.0 – 18.3	8.3	6.8	0.0 – 51.2	18.3	15.2
Cu	7.9 – 39.8	21.0	9.4	7.3 – 22.4	14.3	4.5	13.2 – 52.7	30.3	11.4
Zn	18.6 – 92.6	54.2	27.8	18.5 – 77.4	42.0	18.4	21.3 – 126.9	74.2	32.0
Pb	7.8 – 22.5	13.8	3.9	5.1 – 19.2	11.8	3.3	11.3 – 63.5	27.2	14.8
Cd	0.4 – 6.2	2.0	1.5	0.6 – 3.5	1.4	0.7	0.9 – 8.3	3.2	2.0
Ni	1.9 – 88.9	42.4	24.3	3.5 – 67.9	22.8	24.7	6.9 – 73.6	34.6	18.3

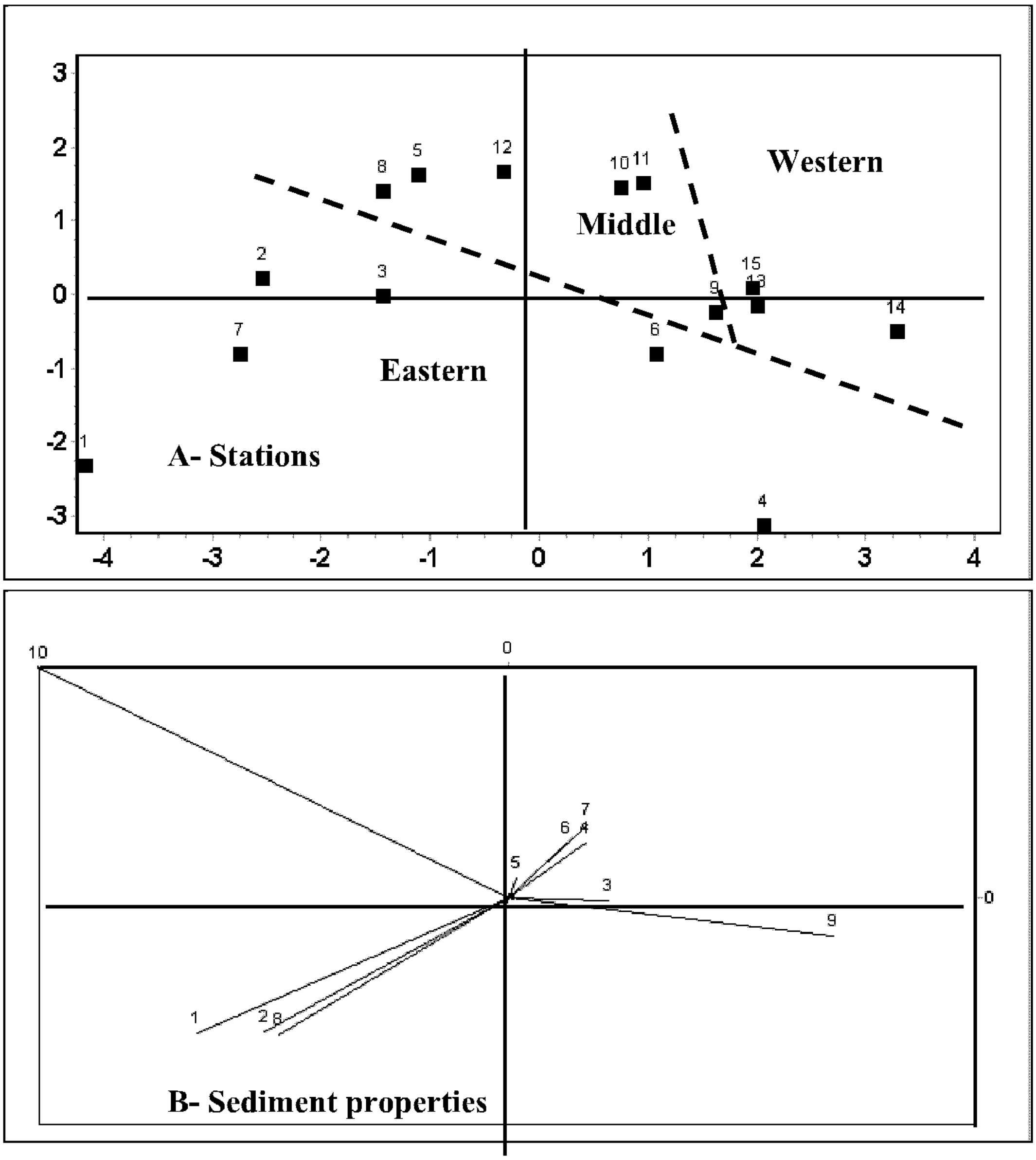

Fig. 3.2. **Principal component analysis (PCA) based on the results of the sediment properties of the 15 sampled stations in Lake Burullus. The sediment properties are: 1: EC, 2: chlorosity, 3: pH, 4: organic matter, 5: Iron, 6: Copper, 7: Zinc, 8: Lead, 9: Cadmium and 10: Nickel.**

stations are very similar to each other (e.g. stations 10 and 11 in the eastern sector, and stations 13 and 15 in the western sector).

3.3.1. Salinity

The sediment salinity of Lake Burullus, as shown by electrical conductivity measurements, depends on the water salinity. The annual mean of water salinity was 2.0 ± 1.8 mS cm^{-1} (Table 3.1), with a minimum of 0.6 mS cm^{-1} at station 15 in the western sector and a maximum of 6.4 mS cm^{-1} at station 1 in the eastern sector (the nearest to the sea outlet). Regarding the spatial variation, the annual mean decreased from east to west (3.1 mS cm^{-1} at east, 1.2 mS cm^{-1} at middle and 0.8 mS cm^{-1} at west). On the other hand, the salinity at the north (2.0 mS cm^{-1}) was higher than the south (1.5 mS cm^{-1}). For both years of sampling (2000 and 2001: Fig. 3.3), the salinity was higher in January (2.5 mS cm^{-1}) than June (1.6 mS cm^{-1}), where the sea water inflows to the lake during this time of the year (El-Shinnawy 2002).

3.3.2. Chlorosity

The chlorosity increases with the increase of salinity. The annual mean was 0.7 ± 0.6 g l^{-1}, with a minimum of 0.2 g l^{-1} at stations 15 (western sector) and a maximum of 2.1 g l^{-1} at station 1 (eastern sector). Regarding the spatial variation, the annual mean was the highest in the eastern sector (1.1 g l^{-1}), and the lowest in the western sector (0.3 g l^{-1}). On the other hand, chlorosity value was similar in the north and south (0.7 g l^{-1}). Temporally, chlorosity has the same trend of salinity where it was higher in January (0.8 g l^{-1}) than in June (0.7 g l^{-1}) due to the inflow of sea water during that time of the year (Radwan 1997, El-Shinnawy 2002).

3.3.3. pH

The annual mean of pH was 7.8 ± 0.4, with a minimum of 7.5 at station 2 (eastern sector) and a maximum of 8.1 at station 13 (western sector). The spatial variation indicates that, the annual mean was 7.8 in the eastern and middle sectors and 7.9 in the western sector. On the other hand, pH was 7.9 at the north and 7.8 at the south. For both years of sampling, the mean of pH was higher in January (7.9) than June (7.7).

3.3.4. Organic Matter

The annual mean of organic matter was 2.8 ± 1.4 %, with a minimum of 0.8 % at station 1 (eastern sector) and a maximum of 5.6 % at station 14 (western sector). Regarding the spatial variation, the annual mean of organic matter was 2.0 % in the east, 3.0 % in the middle and 4.1 % in the west. On the other hand, the organic matter was lower in the north (2.9 %) than in the south (3.1 %). This may be due to the accumulation of dead submerged and floating

hydrophytes abundant in the west and south of the lake. Generally, the organic matter content in the sediment of Lake Burullus was high near the mouths of the drains. The mean of organic matter is slightly increased during June (2.9 %) than during January (2.6 %), where the submerged and floating hydrophytes grow at that time of the year.

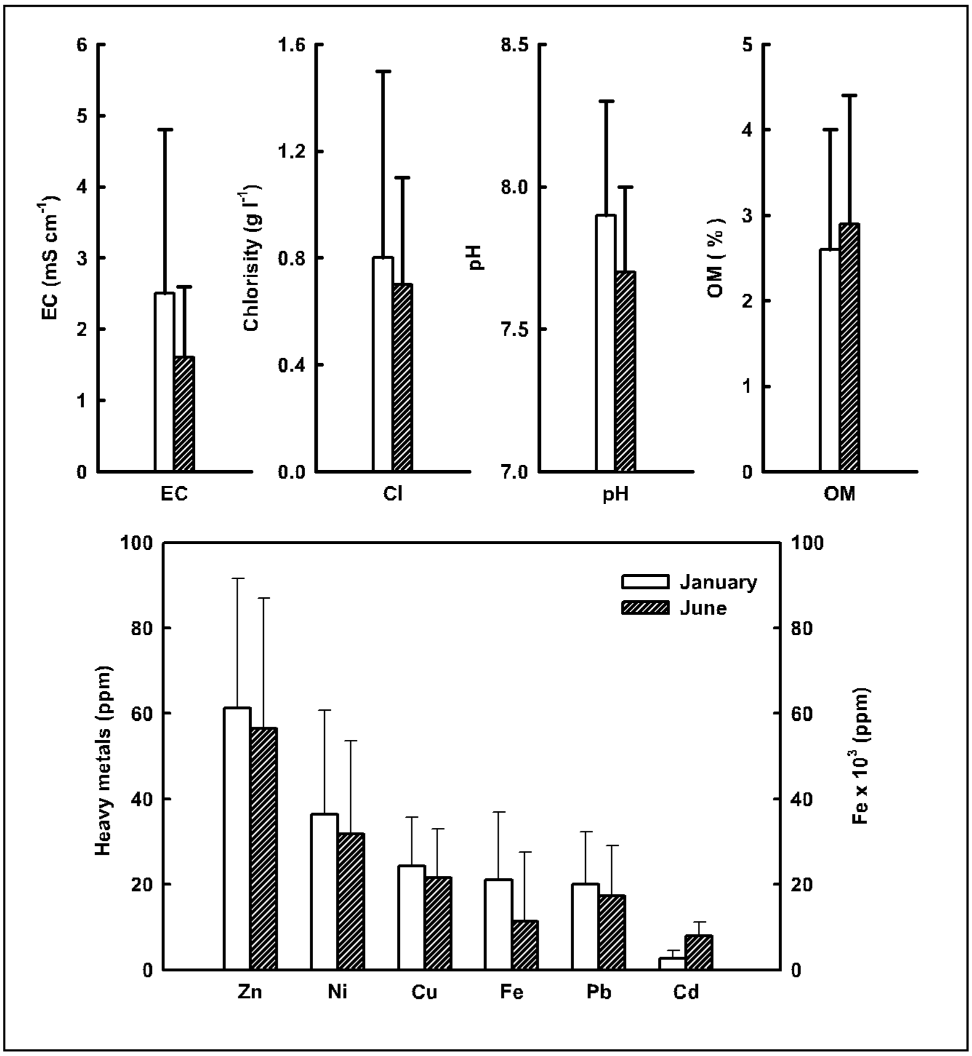

Fig. 3.3. **Temporal variation in the sediment properties in Lake Burullus. The bars at the top of histograms are the standard deviations of the means.**

3.3.5. Heavy Metals

Heavy metals are serious pollutants in natural environment due to their toxicity, persistence and bioaccumulation problems. The impact of anthropogenic perturbation is most strongly felt by estuarine and coastal

environments adjacent to urban areas. Heavy metals from incoming drains, tidal and fresh water sources are rapidly removed from water body and deposited onto the sediments (El-Nemr 2003). The concentration of heavy metals in the sediments of Lake Burullus had the following sequence: Fe > Zn > Ni > Cu > Pb > Cd. This trend is dissimilar to that of the lake water (Zn > Fe > Cu > Cd > Pb). Similar to the trend of heavy metals in the water, most of the estimated heavy metals in the sediments were higher in the south than in the north. This trend could be attributed to the effect of sewage effluents from the drains at the south particularly at the stations near to the mouths of drains with increasing levels of organic matter and the clay nature of the sediments. The nature of bottom sediments reflects to a great extent several conditions resulting from water inputs and the kind of pollutants (Radwan 2001). In addition, the trend of variation along east-west axis was: western sector > eastern sector > middle sector for all the estimated heavy metals except Pb (east > west > middle) and Ni (west > middle > east). On the other hand, January was characterized by higher contents of sediments than June, except cadmium.

3.3.5.1. Iron (Fe)

The annual mean of iron was 16.2 x 10^3 ± 16.6 x 10^3 ppm, with a minimum of 2.7 x 10^3 ppm at station 8 (middle sector) and a maximum of 35.1 x 10^3 ppm at station 1 in the eastern sector. Regarding the spatial variation, the mean values were 15.2 x 10^3 ppm in the east, 10.0 x 10^3 ppm in the middle and 28.7 x 10^3 ppm in the west. On the other hand, the iron was higher at the north (19.8 x 10^3 ppm) than at the south (18.3 x 10^3 ppm). In addition, the mean value was higher in January (21.0 x 10^3 ppm) than in June (11.3 x 10^3 ppm).

3.3.5.2. Copper (Cu)

The annual mean value of copper was 22.9 ± 11.3 ppm, with a minimum of 8.9 ppm at stations 2 (eastern sector) and a maximum of 47.3 ppm at station 4 in the same sector. The spatial variation indicates that the mean values were 22.1 ppm in the east, 19.7 ppm in the middle and 30.4 ppm in the west. On the other hand, the mean was lower in the north (21.0 ppm) than in the south (30.3 ppm). The temporal variation indicated that the mean of copper was higher in January (24.3 ppm) than in June (21.6 ppm).

3.3.5.3. Zinc (Zn)

Zinc has the highest values of heavy metals in the sediments of Lake Burullus, with an annual mean of 58.9 ± 30.2 ppm. It had a minimum of 22.2 ppm at station 8 (middle sector) and a maximum of 119.7 ppm at station 4 (eastern sector). Regarding the variation along east-west axis, the mean value was lower in the east (51.7 ppm) than the west (89.2 ppm). On the other hand, it was lower in the north (54.2 ppm) than the south (74.2 ppm). The content of zinc was higher during January (61.3 ppm) than June (56.5 ppm).

3.3.5.4. Lead (Pb)

The lead had an annual mean value of 18.6 ± 12.0 ppm, with a minimum of 8.7 ppm at station 10 (middle sector) and a maximum of 54.8 ppm at station 4 in the eastern sector. Regarding the spatial variation, the mean value in the east was 22.4 ppm, that of the middle was 12.8 ppm and that of the west was 19.4 ppm. On the other hand, the lead was lower at the north (13.8 ppm) than the south (27.2 ppm). Temporally, the mean was higher in January (20.0 ppm) than June (17.3 ppm).

3.3.5.5. Cadmium (Cd)

The cadmium had the lowest value of all the estimated heavy metals in the sediments of Lake Burullus, with an annual mean value of 5.3 ± 22.7 ppm, a minimum of 0.8 ppm at station 12 (middle sector), and a maximum of 45.9 ppm at station 4 (eastern sector). Regarding the variation along east-west axis, the mean value in the east (2.3 ppm) was higher than the middle (2.1 ppm) and west (3.0 ppm). On the other hand, cadmium and similar to the other heavy metals, was lower at the north (2.0 ppm) than the south (3.2 ppm). Temporally, the mean of Cd was lower in January (2.7 ppm) than June (7.9 ppm).

3.3.5.6. Nickel (Ni)

The annual mean value of nickel in the sediment was 34.0 ± 23.1 ppm, with a minimum of 3.3 ppm at station 1 (eastern sector) and a maximum of 72.5 ppm at station 13 (western sector). The spatial variation indicated that the mean value was lower at the east (16.3 ppm) than the west (34.0 ppm). On the other hand, the mean value of nickel was 42.4 ppm at the north and 34.6 ppm at the south. In addition, the mean was higher in January (36.3 ppm) than June (31.7 ppm).

3.3.6. Correlation Between the Sediment Properties

Similar to that of water properties, the simple linear correlation coefficient between the salinity and chlorosity of the sediments in Lake Burullus is significant positive ($r = 0.97$, $P < 0.001$). On the other hand, and unlike to the water properties, the correlations between both variables and Zn were negative, although it did not reach the significant level in case of chlorosity with Zn (Table 3.4). In addition to the previous correlations, organic matter had significant negative correlation with salinity ($r = 0.74$, $P < 0.01$) and chlorosity ($r = 0.77$, $P < 0.001$), while the heavy metals Cu, Zn and Pb had significant positive correlation with each other.

Table 3.4. **Matrix of Pearson simple linear correlation coefficients (r) between sediment properties in Lake Burullus. *: P < 0.05, **: P < 0.01, ***: P < 0.001.**

Variable	EC	Cl	pH	OM	Heavy metal		
					Cu	Zn	Pb
EC	---	0.97***	-0.14	0.74**	-0.47	-0.52*	-0.22
Cl		---	-0.01	-0.77***	-0.34	-0.47	-0.06
pH			---	-0.06	0.29	0.06	0.18
OM				---	0.33	0.45	0.16
Cu					---	0.89***	0.71**
Zn						---	0.63*
Pb							---

3.3.7. Correlation Between Water and Sediment Properties.

As indicated in Fig. 3.5., the similar variables that have significant positive correlations in the water and sediment are EC ($r = 0.92$, $P < 0.001$), Cl ($r = 0.96$, $P < 0.001$) and Pb (0.59, $P < 0.05$). Some other variables had positive insignificant correlations ($P > 0.05$) such as pH ($r = 0.21$), Cu ($r = 0.39$), and Fe ($r = 0.36$); or insignificant negative correlations such as Zn ($r = -0.27$) and Cd ($r = -0.06$).

3.3.8. Comparison with the Other Water Bodies

The heavy metals concentrations in the sediments of Lake Burullus, as indicated in the present work, are much lower than those of Danube River (Woitke *et al.* 2003) and Rias Baixas in NW Spain. The exaggerated figures in the study of El-Nemr (2003) on the sediments of Lake Burullus is due to the instantaneous sampling of his study (January 2003) comparing with the all-year average of the present work (monthly samples from January to December 2001). On the other hand, the annual average is less than the effect-range law for all elements except the cadmium (Table 3.5). In case of exceeding the effect – range law, the incidence of biological effects increased to 20 – 30 % for most trace elements. When the values exceed effect-range-median the incidence increased to 60 – 90 % (El-Nemr 2003).

Analysis of the labile (leachable) metal fraction of the sediment may be more useful in terms of discovering its biological significance and the new inputs, than the analysis of the total metal fraction (Lacerda *et al* 1992, Paente *et al.* 1996). Based on the analyses of labile and total fractions in the sediments, the study of El-Nemr (2003) indicated new inputs of the estimated heavy metals (Fe, Ni, Zn, Pb, Cd and Zn) in the sediments of Lake Burullus.

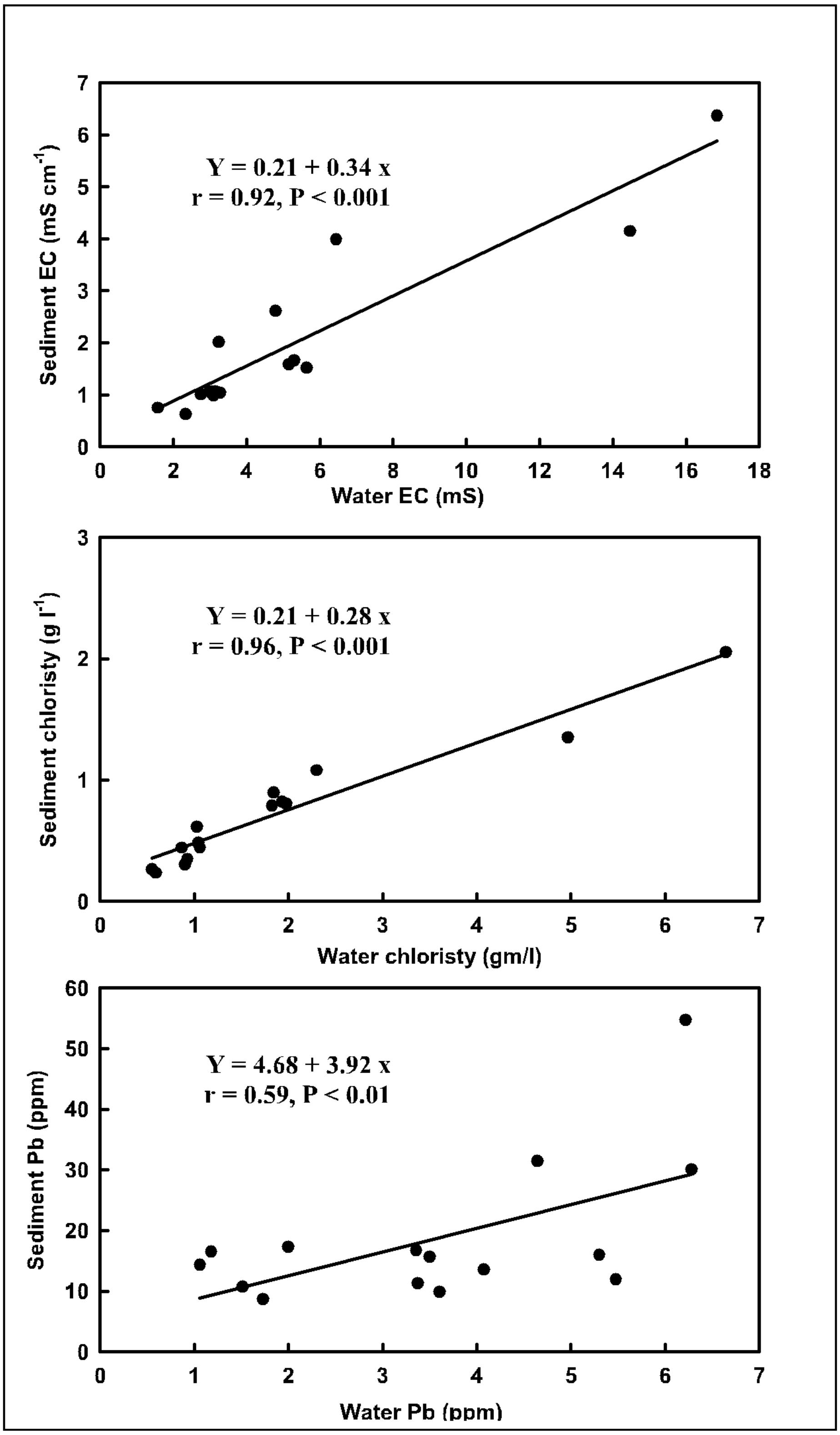

Fig. 3.5. **Simple linear regression between the similar variables in the water and properties of Lake Burullus.**

Table 3.5. **Comparison between the heavy metals in the sediments of Lake Burullus and the sediments of some European water bodies. ERL: effect-range-law, ERM: effect range-medean, NA: not available.**

Heavy metal	Lake Burullus		Danube River	Rias Baixas		
	The present study	El-Nemr 2003	Woitke *et al.* 2003	Villares *et al.* 2003	ERL	ERM
Fe x 10^3	21.6 ± 15.9	25.2 ± 10.4	29.7	23.0	NA	NA
Cu	24.3 ± 11.3	113.1 ± 43.7	65.7 ± 12.3	10.9 ± 15.8	34.0	270
Zn	61.4 ± 30.5	78.4 ± 27.5	187.0± 5.0	41.0 ± 27.1	150	410
Pb	19.7 ± 12.1	60.2 ± 12.5	46.3 ± 6.8	43.3 ± 27.1	46.7	218
Cd	2.9 ± 2.9	9.6 ± 1.5	1.2 ± 0.4	---	1.2	9.6
Ni	35.5 ± 23.8	78.5 ± 13.6	49.6 ± 6.1	---	20.9	51.6

3.4. SUMMARY

The bottom sediments along the northern shores extending from the lake-sea connection westwards, are mainly clayey- and silty-sand with some patches of molluscan shells. The eastern and western sites of the lake are silty-clay. The southern shore sediments, which receive directly the drain discharge, are mainly formed of clay and silt with small areas covered with molluscan shells. A significant reduction in sedimentation rates in Lake Burullus happened after approximately 1960. The trend of the pre-1960 biostratigraphic dates suggests that the first significant freshwater changes can be approximately dated to 1920. The pre-1960 sedimentation rate was calculated to be 0.32 g cm^{-2} yr^{-1} (3.9 mm yr^{-1}), which was significantly higher than the post-1960 value of 0.075 g cm^{-2} yr^{-1} (2.1 mm yr^{-1}).

The bottom sediments of Lake Burullus were collected from fifteen stations during winter (January) and summer (June) of 2000 and 2001. The samples were prepared to estimate the following properties: salinity, chlorisity, acidity, organic matter and heavy metals (Fe, Cu, Zn, Pb, Cd and Ni). Comparable to the PCA ordination of the same 15 stations based on the water properties, the PCA ordination based on sediment properties indicates a clear separation between the stations of the eastern, middle and western sectors of the lake.

The annual mean of sediment salinity was 2.0 mS cm^{-1} with a spatial annual range of 0.6 - 6.4 mS cm^{-1}. For both years of sampling (2000 and 2001), the salinity was higher in January (2.5 mS cm^{-1}) than June (1.6 mS cm^{-1}). The annual mean of chlorosity was 0.7 g l^{-1}, with a spatial range of 0.2 g l^{-1} - 2.1 g l^{-1}. Temporally, chlorosity had the same trend of salinity where it was higher in January (0.8 g l^{-1}) than June (0.7 g l^{-1}) due to the inflow of sea water to the lake winter months. The annual mean of pH was 7.8, with a range of 7.5 - 8.1. For

both years of sampling, the mean of pH was higher in January (7.9) than in June (7.7). Regarding the organic matter, the annual mean was 2.8 %, with a spatial range of 0.8 - 5.6 %. In contrast with the properties, the mean of organic matter was lower in January (2.6 %) than in June (2.9 %).

The concentration of heavy metals in the lake sediments had the following sequence: Fe > Zn > Ni > Cu > Pb > Cd, with annual means of 16.2×10^3, 58.9, 34.0, 22.9, 18.6 and 5.3 ppm, respectively. This trend is dissimilar to that of lake water (Zn > Fe > Cu > Cd > Pb). In addition, the trend of variation along east-west axis was: western sector > eastern sector > middle sector for all metals except Pb (east > west > middle) and Ni (west > middle > east). The spatial ranges in ppm were 2.7×10^3-35.1×10^3 (Fe), 22.2-119.7 (Zn), 3.3-72.5 (Ni), 8.9- 47.3 (Cu), 8.7- 54.8 (Pb) and 0.8- 45.9 (Cd). On the other hand, the sediments were characterized by higher contents of heavy metals in January than in June except Cd. The January-June ranges in ppm were 11.3×10^3-21.0×10^3 (Fe), 56.5-61.3 (Zn), 31.7-36.3 (Ni), 21.6-24.3 (Cu), 17.3-20.0 (Pb) and 2.7-7.9(Cd).

Similar to the water properties, the simple linear correlation coefficient between the sediment salinity and chlorosity was significant positive. On the other hand, and unlike to the water properties, the correlations between both variables and Zn are negative, although it does not reach the significant level in case of chlorosity with Zn. In addition to the previous correlations, organic matter had significant negative correlation with salinity and chlorosity, while the heavy metals Cu, Zn and Pb have significant positive correlations with each other. The smae water and sediment variables that had significant positive correlations were EC, Cl and Pb.

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Chapter 4
Flora and Vegetation

4.1. FLORA

4.1.1. Annotated Checklist

The recorded species in Burullus Wetland are arranged according to Engler system as reported by Täckholm (1974) and Boulos (1995). Accepted names are in bold and synonyms are in italic types. The abbreviation of the sex forms are: Di: Dioecious, Mo: Monoecious, Bi: Bisexual. The life forms are as follows: Ph: phanerophytes, Ch: chamaephytes, H: hemicryptophytes, GH: geophytes-helophytes, HH: hydrophytes, Th:therphytes and P: parasites. The vernacular name of each species is mentioned after its life form.

(1) AZOLLACEAE

1- ***Azolla filiculoides*** Lam.: Spores, HH, Azolla, آزولا

(2) SALICACEAE

2- ***Salix tetrasperma*** Roxb.: Di, Ph, Safsaf afrangi, صفصاف أفرنجى

(3) POLYGONACEAE

3- *Emex spinosa* (L.) Campd.: Mo, Th, Dirs el-agooz, ضرس العجوز

4- *Persicaria salicifolia* (Willd.) Assenov in Jordanov: Bi, GH, Zelfa, زلفه
Syn. *Polygonum salicifolium* Brouss. ex Willd.

5- *Persicaria senegalensis* (Meisn.) Soják: Bi, GH, لسان العصفور
Syn. *Polygonum senegalense* Meisn.

6- *Polygonum equisetiforme* Sibth. & Sm.: Bi, GH, Qordaab, قرضاب

7- *Rumex dentatus* L.: Bi, Th., Khilla, خلا

8- *Rumex pictus* Frossk.; Bi, TH, Hamsees, حمصيص
Syn. *Rumex lacerus* Balb.

(4) AIZOACEAE

9- *Mesembryanthemum crystallinum* L.: Bi, Th, Ghasool, غسول

10- *Mesembryanthemum nodiflorum* L.: Bi, Th, Samh, سمح

(5) PORTULACACEAE

11- *Portulaca oleracea* (L.) Bi, Th, Rigla, رجلة

(6) CARYOPHYLLACEAE

12- *Paronychia arabica* (L.) Dc. in Lam.: Bi, Th, Simreeb سمريب

13- *Silene succulenta* Frossk.: Bi, H, Khobeyzet el-bahr خبيزة البحر

14- *Silene villosa* Forssk.: Bi, Th, Attaan عطان

15- *Spergula fallax* (Lowe) E.H.L. Krause in Sturm: Bi, Th, Gileglaag, جيلجلاج
Syns. *Spergularia fallax* Lowe
Spergularia flaccida Asch.

16- *Spergularia marina* (L.) Griseb.: Bi, Th, Abu gholaam, أبو غلام
Syns. *Arenaria rubra* L. var. *marina* L.
Arenaria marina (L.) All.
Spergularia salina J. & C. Presl

(7) CHENOPODIACEAE

17- *Agathophora alopecuroides* (Delile) Fenzl ex Bunge: Bi, Ch, Hamd, حمد
Syns. *Anabasis alopecuroides* (Delile) Moq. in A. Dc.
Halogeton alopecuroides (Delile) Moq.
Salsola alopecuroides Delile

18- *Arthrocnemum macrostachyum* (Moric.) K. Koch.: Bi, Ch, Shinaan, شنان
Syns. *Arthrocnemum glaucum* (Delile) Ung.-Sternb.
*Arthrocnemum macrostachyum (*Moric.) Moris

Salicornia macrostachya Moric.

Salicornia glauca Delile

19- ***Atriplex canescens*** (Pursh) Nutt.: polygamous, Ch, Qataf, قطف

Syn. *Calligonum canescens* Pursh

20- ***Atriplex halimus*** L.: polygamous, Ph, Roghaata, رجات

21- ***Atriplex leucoclada*** Boiss.: polygamous, Ch, Shagaret el-bayydeen شجرة البياضيين

22- ***Atriplex nummularia*** Lindl. in T.L. Mitchell: polygamous, Ch, Qataf, قطف

23- ***Atriplex portulacoides*** L.: polygamous, Ch, Qataf, قطف

24- ***Bassia indica*** Wight A.J. Scott: Bi, Th, Kokhia, كوخيا

Syns. *Bassia joppensis* Bornm. & Dinsm.

Kochia indica wight

Kochia scoparia (L.) Schrad. subsp. *indica* (wight) Aellen

25- ***Beta vulgaris*** subsp. ***maritima*** (L.) Arcang.: Bi, Th, Salq, سلق

Syns. *Beta maritima* L.

Beta perennis (L.) Halácsy

Beta vulgaris subsp. *perennis* (L.) Aellen in Heigi

26- ***Chenopodium album*** L.: Bi, Th, Rokab el-gamal, ركب الجمل

27- ***Chenopodium ambrosioides*** L.: Bi, Th, Zorbeh, زربيح

28- ***Chenopodium glaucum*** L.: Bi, Th, Minteena منتنة

29- ***Chenopodium murale*** L.: Bi, Th, Lisaan et-thor, لسان الثور

30- ***Chenopodium opulifolium*** Schrod. ex Koch and Ziz.: Bi, Th, Fissa el-kilaab فسا الكلاب

31- ***Cornulaca monacantha*** Delile: polygamous, Ch, Shook el-deeb شوك الديب

32- ***Halocnemum strobilaceum*** (Pallas) M. Bieb.:Bi, Ch, Hatab haddadi, حطب حدادى

Syn. *Salicornia strobilacea* Pall.

Salicornia cruciata Forssk.

33- ***Salsola kali*** (L.): Bi, Th, Eshnaan, إشنان

34- ***Sarcocorinia fruticosa*** (L.) A.J. Scott: Bi, Ch, Abu saaq, أبو ساق

Syns. *Arthrocnemum fruticosum* L.) Moq.

Salicornia europaea var. *fruticosa* L.

Salicornia fruticosa (L.) L.

35- ***Suaeda maritima*** (L.) Dumort.: Bi, Ch, Khreiza, خريزة

Syns. *Chenopodium maritimum* L.

Chenopodium salsum L.

Suaeda salsa (L.) Pall.

36- ***Suaeda pruinosa*** Lange: Bi, Ch, Hatab sweidi, حطب سويدى

37- ***Suaeda vera*** Forssk. ex J.F. Gmel.:Bi, Ch, Sabath, سبطه

Syns. *Chenopodium fruticosum* L.

Salsola fruticosa (L.) L.

Suaeda fruticosa (L.) Dumort.
Suaeda fruticosa subsp. *vera* (Forssk. ex J.F. Gmel.) Maire & Weiller in Maire

(8) AMARANTHACEAE

38- *Alternanthera sessilis* (L.) Dc.: Bi, GH, Loqmet el-hamal, لقمة الحمل
Syns. *Alternanthera repens* J.F. Geml.
Gomphrena sessilis L.

39- *Amaranthus hybridus* subsp. ***hybridus*** L.: Mo, Th, Ro'aaf, رعاف
Syns. *Amaranthus chlorostachys* Willd.
Amaranthus hypochondriacus L.
Amaranthus patulus Bertol.

40- *Amaranthus lividus* L.: Mo, Th, Amaranthoan, أمارنطون
Syns. *Amaranthus ascendens* Loisel.
Amaranthus biltum L.
Amaranthus lividus subsp. *polygonoides* (Moq.) Probst
Amaranthus oleraceus L.

41- *Amaranthus viridis* L.: Mo, Th, Kabshoo-lignah, كبشولجناح
Syns. *Albersia caudata* (Jacq.) Boiss.
Amaranthus gracilis Poir. in Lam.

(9) RANUNCULACEAE

42- *Adonis dentata* Del.: Bi, Th, Na'ab el-gamal, ناب الجمل
43- *Ranunculus marginatus* d' Urv.: Bi, Th, Shaqeeq شقيق
44- *Ranunculus sceleratus* L.: Bi, Wetland hydrophytes, Zaghalanta, زغلنته

(10) CERATOPHYLLACEAE

45- *Ceratophyllum demersum* L.: Mo, HH, Nakshhoosh el-hoot, نخشوش الحوت
46- *Ceratophyllum submersum* L.: Mo. HH, Horeish, حوريش

(11) BRASSICACEAE

47- *Brassica tournefortii* Gouan: Bi, Th, Shiltaam, شلطام
48- *Brassica rapa* L.: Bi, Th, Kabar, كبر
49- *Cakile maritima* Scop.: Bi, Th, Rashaad el-bahr, رشاد البحر
Syns. *Cakile aegyptiaca* Willd.
Cakile hispanica Jord.
Cakile littoralis Jord.
Cakile maritima subsp. *aegyptiaca* (Willd.) Nyman

50- *Coronopus didymus* (L.) Sm.: Bi, Th, Rashaad el-barr, رشاد البر

Syns. *Lepidium didymum* L.
Senebiera didyma (L.) Pers.

51- ***Coronopus squamatus*** (Forssk.) Aschers.: Bi, Th, Harra, حرّى
Syn. *Lepidium squamatum* Forssk.

52- ***Eruca sativa*** Mill.: Bi, Th, Gargeer, جرجير
Syn. *Eruca vesicaria* (L.) Cav. subsp. *sativa* (Miller) Thell.

53- ***Lobularia arabica*** (Boiss.) Muschl.: Bi, Th, Dahyaan دحيان
Syns. *Lunaria libyca* Viv.
Koniga libyca (Viv.) R. Br.

54- ***Raphanus raphanistrum*** L.: Bi, Th, Figl, فجل

55- ***Rapistrum rugosum*** (L.) All.: Bi, Th,
Syns. *Myagrum rugosum* L.
Rapistrum orientale (L.) Crantz

56- ***Rorippa palustris*** (L.) Besser: Bi, Th,
Syns. *Sisymbrium amphibium* L. var. *palustre* L.
Nasturtium palustre (L.) DC.
Rorippa islandica, sensu Tackholm

57- ***Sinapis arvensis*** subsp. ***allionii*** (Jacq.) Baillarg: Bi, Biennials, Khardal, خردل
Syns. *Sinapis allionii* Jacq.
Sinapis turgida (Pers.) Delile

58- ***Sisymbrium irio*** L.: Bi, Th, Figl el-gamal فجل الجمل

(12) LEGUMINOSAE

59- ***Alhagi graecorum*** Bioss.: Bi, Ch, Aqool, عاقول
Syns. *Alhagi mannifera* Jayb. & Spach
Alhagi maurorum Medic.

60- ***Astragalus boeticus*** L.: Bi, Th, Mahallaq محلاق

61- ***Astragalus peregrinus*** Vahl.: Bi, Th, Kreishet el-homaar كريشة الحمار

62- ***Lathyrus marmoratus*** Bioss. & Bl. in Bioss.: Bi, Th, Dohreig, دُحريج

63- ***Lotus arabicus*** L.: Bi, Th, Gatb, جطب

64- ***Lotus halophilus*** Bioss & Spruner in Bioss.: Bi, Th, Rigl el-asfoor, رجل العصفور
Syns. *Lotus villosus* Forssk.
Lotus pusillus Viv.

65- ***Medicago intertexa*** var. ***ciliaris*** (L.) Heyn: Bi, Th, Khaasag, خاصج
Syns. *Medicago ciliaris* (L.) All.
Medicago polymorpha var. *ciliaris* L.

66- ***Medicago polymorpha*** L.: Bi, Th, Nafal, نَفَل
Syns. *Medicago denticulata* Willd.

Medicago nigra Krock.
67- ***Melilotus indicus*** (L.) All. : Bi, Th, Handaqooq, حنـدقوق مـر
Syns. *Melilotus bonplandii* Ten.
Melilotus parviflorus Desf.
Melilotus tommasinii Jord.
Trifolium indicum L.
68- ***Trifolium alexandrinum*** L.: Bi, Th, Berseem, بـرسيم
69- ***Trifolium resupinatum*** L. : Bi, Th, Goreida, جـريــده
Syn. *Trifolium suaveolens* Willd.
70- ***Trigonella laciniata*** L. : Bi, Th, Deraaq, دِرّاق
71- ***Trigonella stellata*** Forssk.: Bi, Th, Shetn el-khaadem شطن الخادم
72- ***Vigna luteola*** (Jacq.) Benth. in Mart.: Bi, Ch, Lobya, لوبيا

(13) GERANIACEAE

73- ***Erodium laciniatum*** (Cav.) Willd.: Bi, Th, Abu mosfaah, أبو مصـفاح
Syns. *Geranium laciniatum* Cav.
Erodium affine Ten.
Erodium pyramidatum C. Presl

(14) ZYGOPHYLLACEAE

74- ***Fagonia arabica*** L.: Di, Ch, Aqool el-ghazal عاقول الغزال
75- ***Zygophyllum album*** subsp. ***album*** L. f. : Bi, Ch, Ratrayt, رطـريـط

(15) EUPHORBIACEAE

76- ***Euphorbia peplis*** L. : Mo, Th, Libbeina, لبـيـنـه
Syn. *Tithamnus peplis* (L.) Scop.
77- ***Ricinus communis*** L. :Mo, Trees, Kharwaa, خـروع

(16) MALVACEAE

78- ***Malva parviflora*** L.: Bi, Th, Khobbeiza, خبيـزه
79- ***Sida alba*** L. : Bi, H, Melohkiet eblees, ملوخية إبليس
Syn. *Sida spinosa* L.

(17) TAMARICACEAE

80- ***Tamarix aphylla*** (L.) Karst.: Bi, Ph, Atl آتل
Syns. *Thuja aphylla* L.
Tamarix articulata Vahl
81- ***Tamarix nilotica*** (Ehrenb.) Bunge: Bi, Ph, Moor, مــور
Syns. *Tamarix arabica* Bunge

Tamarix arborea (Ehrenb.) Bunge
Tamarix mannifera Bunge
82- ***Tamarix tetragyna*** Ehrenb: Bi, Ph, Dehaseer دحسير

(18) FRANKENIACEAE

83- ***Frankenia revoluta*** Forssk. : Bi, H, Hemeisha, حميشه
Syn. *Frankenia hirsuta* L. var. *revoluta* (Forssk.) Boiss.
84- ***Frankenia pulverulenta*** L.: Bi, Th, Molleih مُليح

(19) ONAGRACEAE

85- ***Ludwigia stolonifera*** (Guill & Perr.) P.H. Raven : Bi, HH, Moddad, مّدَّاد
Syns. *Jussiaea repens* sensu Boiss.
Jussiaea stolonifera Guill. & Perr. in Guill.

(20) CYNOMORIACEAE

86- ***Cynomorium coccineum*** L.: Bi, GH, P, Marshoosh مرشوش

(21) UMBELLIFERAE

87- ***Ammi visnaga*** (L.) Lam. : Bi, Th, Khilla, خله
Syn. *Daucus visnaga* L.
88- ***Anethum graveolens*** L.: Bi, Th, Shabbat, شَبَت
89- ***Coriandrum sativum*** L.: Bi, Th, Kozbara, كزبره

(22) PRIMULACEAE

90- ***Anagallis arvensis*** L. : Bi, Th, Ain el-gamal, عين الجمل

(23) PLUMBAGINACEAE

91- ***Limoniastrum monopetalum*** (L.) Bioss. in A. DC. : Bi, Ch, Zeita, زيته
Syn. *Statice monopetala* L.
92- ***Limonium pruinosum*** (L.) Chaz.: Bi, GH, Molleih, مُليح

(24) ASCLEPIADACEAE

93- ***Cynanchum acutum*** L.: Bi, Ph, Olleiq, عُليق
Syn. *Cynanchum monospeliacum* L.

(25) CONVOLVULACEAE

94- ***Convolvulus arvensis*** L.: Bi, H, Olleiq, عُليق
Syns. *Convolvulus auriculatus* Desr. in Lam.

Convolvulus longipedicellatus Sa=ad

95- ***Convolvulus lanatus*** Vahl: Bi, Ph, Bayaad بياضه

96- ***Cressa cretica*** L.: Bi, H, Molleih, مُليح

97- ***Ipomoea carnea*** Jacq. : Bi, H, Olleiq ek-kibeer, عْليق الكبير

(26) BORAGINACEAE

98- ***Heliotropium curassavicum*** L.: Bi, Ch, Ghbbeira غُبيره

Syns. *Heliotropium glaucum* Salisb.

Heliotropium glaucophyllum Moench

Heliotropium chenopodiodes Willd.

(27) VERBENACEAE

99- ***Clerodendrum acerbianum*** (Vis.) Benth. & Hook. f.: Bi, Ch, Yasmeen zefer ياسمين زفر.

Syn. *Volkameria acerbiana* Vis.

100- ***Phyla nodiflora*** (L.) Greene: Bi, H, Libya, ليبيا

Syns. *Lippia nodiflora* (L.) Michx.

Verbena nodiflora L.

(28) LABIATAE

101- ***Mentha longifolia*** (L.) Huds. : Bi, GH, Na'na, نعنع

Syns. *Mentha lavandulacea* Willd.

Mentha spicata L. var. *longifolia* L.

Mentha sylvestris L.

(29) SOLANACEAE

102- ***Lycium schweinfurthii*** Dammer: Bi, Ph, Awsag, عوسج

(30) OROBANCHACEAE

103- ***Cistanche phelypaea*** (L.) cout.: Bi, P, Daan el-ginn دآن الجن

Syns. *Lathraea phelypaea* L.

Orobanche tinctoria Forssk.

Phelipaea lutea Desf.

Cistanche tinctoria (Forssk.) Brot

Cistanche lutea (Desf.) Hoffmanns

Orobanche phelypaea (L.) Wallr.

Cistanche tinctoria (Forssk.) Beck

Cistanche phelypaea (L.) Cout. subsp. *lutea* (Desf.) fernier in Fernier & Lainz

104- ***Orobanche cernua*** Loefl.: Bi, P, Daan el-'aader دآن العادر

105- *Orobanche crenata* Forssk. : Bi, P, Halouk metabi, هالوك متابى
Syns. *Orobanche speciosa* DC. in Lam. & DC.
Orobanche pruinosa Lapeyr.
Orobanche angusisepala F.W. Schultz
106- *Orobanche ramosa* var. ***schweinfurthii*** (Beck) Hadidy comb. nov.: Bi, P, Halouk, هالوك
Basionym. *Orobanche schweinfurthii* Beck
Syn. *Phelipanche schweinfurthii* (Beck) Sojak

(31) PLANTAGINACEAE

107- *Plantago major* L. : Bi, H, Lisaan el-hamal, لسان الحمل

(32) COMPOSITAE

108- *Aster squamatus* (Spreng.) Hieron ex Sod.: Bi & Mo, Ch, Aster أستر
Syn. *Conyza squamata* Spreng
109- *Calendula arvensis* L.: Mo, Th, Ain es-safra عين الصفرا
Syns. *Calendula aegyptiaca* Pers.
Calendula bicolor Raf.
Calendula persica C.A. Mey.
Calendula cristagalli Viv.
Calendula ceratosperma Viv.
Calendula gracilis DC.
Calendula micrantha Boiss.
110- *Carduus pycnocephalus* L.: Mo, Th, Lisaan el-kalb لسان الكلب
111- *Centauria calcitrapa* L. : Bi, Ch, Shoak, شوك
112- *Centauria pumilio* L. : Di, Ch, Akaash, عكاش
Syn. *Aegialophila pumilio* (L.) Boiss.
113- *Chrysanthemum coronarium* L.: Mo, Oqhowaan, أقحوان
114- *Cichorium endivia* subsp. ***pumilum*** (Jacq.) Cout. : Bi, Th, Sirees, سريس
Syns. *Cichorium intybus* L. subsp. *pumilum* (Jacq.) Ball
Cichorium pumilum Jacq.
115- *Conyza bonariensis* (L.) Cronquist : Mo, Th, Hashishet el-gabal, حشيشة الجبل
Syns. *Conyza ambigua* DC.
Conyza linifolia (Willd.) Täckh.
Erigeron bonariensis L.
Erigeron crispus Pourr.
Erigeron linifolium Willd.
116- *Echinops spinosissimus* Turra: Bi, H, Shouk el-gamal, شوك الجمل

Syn. *Echinops viscosus* DC.
117- ***Eclipta alba*** (L.) Hassk. : Bi, Th, Swweid, سوّيد
Syns. *Eclipta prostrata* L.
Verbesina alba L.
118- ***Filago desertorum*** Pomel: Bi, Th,
119- ***Gnaphalium luteo-album*** L. : Bi, Th, Saboon afreet, صابون العفريت
Syn. *Pseudognaphalium luteo-album* (L.) Hilliard & B.L. Burtt
120- ***Ifloga spicata*** (Forssk.) Sch.-Bip in Webb & Berthal: Bi, Th, Shagaret el-ma'eeza,
Syn. *Chrysocoma spicata* Forssk. شجرة المعيز
121- ***Inula crithmoides*** L. : Bi, Ch, Hatab zeiti, حطب زيتى
Syn. *Limbarda crithmoides* (L.) Dumort.
122- ***Launaea capitata*** (Spreng.) Dandy in F.W. Andrews: Bi, Th, Halawet el-ghozlaan
Syns. *Sonchus capitatus* Spreng. حلوة الغزلان
Lomatolepis glomerata Cass.
Microrhynchus glomeratus (Cass.) Jaub.
Zollikoferia glomerata (Cass.) Boiss.
Launaea glomerata (Cass.) Hook.
123- ***Launaea nudicaulis*** (L.) Hook. f. : Bi, H, Howa, حـوا
Syns. *Chondrilla nudicaulis* L.
Zollikoferia nudicaulis (L.) Boiss.
124- ***Pluchea dioscoridis*** (L.) DC. : Mo, Ph, Barnoof, برنوف
Syns. *Baccharis aegyptiaca* Forssk. ex DC.
Baccharis dioscoridis L.
Conyza dioscoridis L. Desf.
125- ***Reichardia tingitana*** (L.) Roth: Bi, Th, Shideed شديد
Syns. *Scorzonera tingitana* L.
Scorzonera orientalis L.
Picridim tingitanum (L.) desf.
Reichardia tingitana var. *arabica* (Hochst & Steud.) Asch. & Schweinf.
Reichardia tingitana var. *orientalis* (L.) Asch. & Schweinf.
126- ***Senecio glaucus*** subsp. ***coronopifolius*** (Maire) C. Alexander. : Bi, Th, Qorreis,
Syns. *Senecio coronopifolius* Desf. قريص
Senecio desfontainei Druce
Senecio laxiflorus Viv.
127- ***Senecio vulgaris*** L., Bi, Th, Moraar مرار
128- ***Silybum marianum*** (L.) Gaertn : Bi, H, Shouk nassara, شوك نصارى
Syn. *Carduus marianus* L.
129- ***Sonchus asper*** (L.) Hill : Bi, Th, Galawein, جلاوين

130- ***Sonchus macrocarpus*** Boulos & C. Jeffrey: Bi, Th, Galawein, جلاوين
Syn. *Sonchus gigas* Boulos
131- ***Sonchus oleraceus*** L. : Bi, Biennials, Go'odied, جعضيض
Syns. *Sonchus ciliatus* Lam.
Sonchus glaber Gilib.
Sonchus lacerus Willd.
132- ***Sphaeranthus suaveolens*** (Forssk.) DC. :Bi, H, Zirr el-ward, زر الورد
Syns. *Polycephalos suaveolens* Forssk.
Sphaeranthus abyssinicus Steetz in Peters
Sphaeranthus kotschyi Schweinf.
Sphaeranthus suaveolens Forssk. var. *abyssinicus* Steetz
133- ***Urospermum picroides*** (L.) F.W. Schmidt. : Bi, Th, Salis, سليس
Syn. *Tragopogon picroides* L.

(33) HYDROCHARITACEAE

134- ***Najas marina*** L. subsp. ***armata*** (H. Lindb.) Horn: Mo, HH, Hamool, حامول
Syns. *Najas armata* H. Lindb.
Najas delilei Rouy
Najas marina var. *delilei* (Rouy) Maire
Najas marina var. *muricata* (Delile) K. Schum. in Mart.
Najas muricata Delile
135- ***Najas minor*** All.: Mo, HH, Horreish حُريش
Syn. *Caulinia fragilis* Willd.

(34) POTAMOGETONACEAE

136- ***Potamogeton crispus*** L. : Bi, HH, Horreish, حُريش
137- ***Potamogeton pectinatus*** L. :Bi, HH, Deil el-faras, ديل الفرس

(35) LILIACEAE

138- ***Asparagus stipularis*** Forssk.: Bi, GH, Aqool gabal عاقول جبل
139- ***Urginea undulata*** (Desf.) Steinh.: Bi, GH, Basal far'aon بصل فرعون

(36) ALLIACEAE

140- ***Allium roseum*** L.: Bi, GH, Basal بصل

(37) AMARYLLIDACEAE

141- ***Pancratium maritimum*** L.: Bi, GH, Bosseil, بُصيل

(38) PONTEDERIACEAE

142- *Eichhornia crassipes* (Mart.) Solms-Laub in A. DC.: Bi, HH, Ward el-nil, ورد النيل

(39) JUNCACEAE

143- *Juncus acutus* L. : Bi, GH, Sammar morr, سمار مر
Syn. *Juncus spinosus* Forssk.
144- *Juncus bufonius* L. : Bi, Th, Sha'ar el-qird, شعر القرد
145- *Juncus rigidus* Desf. : Bi, GH, Sammar hosr, سمار حصر
Syns. *Juncus arabicus* (Asch. & Buchenau) Adamson
Juncus maritimus var. *arabicus* Asch. & Buchenau in Boiss.
146- *Juncus subulatus* Forssk. : Bi, GH, Sammar, سمار

(40) GRAMINEAE

147- *Aeluropus lagopoides* (L.) Trin. ex Thwaites : Bi, GH, Nigeel sheitaani, نجيل شيطانى
Syn. *Dactylis lagopoides* L.
148- *Aeluropus littoralis* (Gouan) Parl.: Bi, GH, Yasniu, يسينو
Syn. *Poa littoralis* Gouan
149- *Avena fatua* L. : Bi, TH, Zommeyr, زُمّير
150- *Bromus catharticus* Vahl. : Bi, Th, Abu fakhour, أبو فخور
Syn. *Bromus willdenowii* Kunth
151- *Cutandia dichotoma* (Forssk.) Trab. in Batt. & Trab.: Bi, Th, Sammah, صامه
Syns. *Festuca dichotoma* Forssk.
Scleropa dichotoma Parl.
152- *Cutandia memphitica* (Spreng.) K. Richt.: Bi, Th, Khaafoor, خفور
Syns. *Dactylis memphetica* Spreng.
Scleropa memphetica (Spreng.) Parl
153- *Cynodon dactylon* (L.) Pers. : Bi, GH, Nigeel, نجيل
Syns. *Cynodon glabratus* Steud.
Panicum dactylon L.
154- *Echinochloa colona* (L.) Link : Bi, Th, Aburukba, أبو ركبه
Syns. *Echinochloa colonum* (L.) Link
Panicum colonum L.
155- *Echinochloa crusgalli* (L.) P. Beauv. : Bi, Th, Dineiba, دنيبه
Syn. *Panicum crusgalli* L.
156- *Echinochloa stagnina* (Retz.) P. Beauv. : Bi, GH, Niseela, نسيله
Syn. *Panicum stagninum* Retz.
Echinochloa stagninum (Retz) Beauv.
157- *Elymus farctus* (Viv.) Runemark ex Melderis: Bi, GH.
Syn. *Triticum farctum* Viv.

158- ***Hordeum murinum*** subsp. ***leporinum*** (Link) Arcang. : Bi, Th, Reesh abu el-hossein, ريش أبو الحسين
Syn. *Hordeum leporinum* Link

159- ***Hordeum vulgare*** **L.**: Bi, Th شعير

160- ***Hordeum marinum*** Huds. : Bi, Th, Bahma, بهمى

161- ***Imperata cylindrica*** (L.) Raeusch. : Bi, GH, Halfa, حلفا
Syns. *Imperata arundinacea* Cirillo
Lagurus cylindricus L.
Saccharum koenigii Retz.

162- ***Lolium multiflorum*** Lam. : Bi, Th, Simbil, سمبل

163- ***Lolium perenne*** L. : Bi, Th, Hasheesh el-faras, حشيش الفرس

164- ***Lolium temulentum*** L. : Bi, Th, Zawaan, زوان

165- ***Panicum turgidum*** Forssk. : Bi, GH, Abu rokba, أبو رُكبة

166- ***Parapholis incurva*** (L.) C.E. Hubb.: Bi, Th.
Syns *Aegilops incurva* L.
Lepturus incurvatus (L.) Trin.
Pholiurus incurvus (L.) Schinz & Thell.

167- ***Parapholis marginata*** Runemark : Bi, Th.

168- ***Paspalidium geminatum*** (Forssk.) Stapf. in Prain : Bi, GH, Nesela, نسيله
Syns. *Panicum geminatum* Forssk.
Panicum fluitans Retz.

169- ***Paspalum distichum*** L. : Bi, GH, Moddeid, مديد
Syn. *Digitaria paspalodes* Michx.
Paspalum paspalodes (Michx.) Scribn.

170- ***Phalaris minor*** Retz. : Bi, Th, Shair el-far, شعير الفار

171- ***Phalaris paradoxa*** L. : Bi, Th, Kharfaar, خرفار

172- ***Phragmites australis*** (Cav.) Trin. ex Steud. : Bi, Emerged hydrophytes, Boos, بوص
Syns. *Arundo australis* Cav.
Phragmites communis Trin.

173- ***Poa annua*** L. : Bi, Th, Sabal abu el-hossein, سبل أبو الحسين

174- ***Polypogon monspeliensis*** (L.) Desf. : Bi, Th, Deil el-qott, ديل القط
Syns. *Alopecurus monspeliensis* L.
Phalaris cristata Forssk.

175- ***Polypogon viridis*** (Gouan) Breistr : Bi, H, Deil el-far, ديل الفار
Syns. *Agrostis verticillata* Vill.
Agrostis viridis Gouan
Phalaris semiverticillata Forssk.
Polypogon semiverticillatus (Forssk.) Hyl.

176- ***Saccharum spontaneum*** L.: Bi, GH, Heesh, هيش

177- *Schismus barbatus* (L.) Thell.: Bi, Th, Zaghab el-faar زغب الفار
Syns. *Festuca barbata* L.
Schismus calycinus (L.) K. Koch
178- *Setaria verticillata* (L.) Beauv.: Bi, Th, Qamh el-faar, قمح الفار
Syn. *Panicum verticillatum* L.
179- *Setaria viridis* (L.) P. Beauv. : Bi, Annual grasses, Deil el-far, ديل الفار
Syn. *Panicum viride* L.
180- *Sphenopus divaricatus* (Gouan) Rchb. : Bi, Annual grasses.
Syn. *Poa divaricata* Gouan
181- *Sporobolus pungens* (Schreb.) Kunth: Bi, Th, Nigeel shoaki نجيل شوكى
Syns. *Agrostis pungens* Schreb.
Sporobolus arenarius (Gouan) Duval-Jouve
Sporobolus virginicus (L.) Kunth
182- *Vossia cuspidata* (Roxb.) Griff.: , GH.
Syns. *Ischaemum cuspidatum* Roxb.
Vossia procera Wall. & Griff.

(41) PALMAE

183- *Phoenix dactylifera* L. : Di, Ph, Nakhl el-balah, نخل البلح

(42) LEMNACEAE

184- *Lemna gibba* L.: Bi, HH, Ads el-mayya, عدس الميه
185- *Lemna perpusilla* Torrey: Bi, HH, Ads el-mayya, عدس الميه
Syns. *Lemna aequinoctiale* Welw. ex Hegelm.
Lemna angolensis Hegelm.
Lemna paucicostata Engelm. in Gray
186- *Pseudowolffia hyalina* (Delile) Hartog & Pals:Bi, HH, Reem ريم
Syns. *Lemna hyalina* Delile
Wolffia delilei Schled.
Wolffia hyalina (Delile) Hegelm.
Wolffiella hyalina (Delile) Monod

(43) TYPHACEAE

187- *Typha domingensis* (Pers.) Poir ex Steud. : Mo, GH, Bordi, بردى
Syns. *Typha angustata* Bory & Chaub. in Bory
Typha australis Schum. & Thonn. in Schum.

(44) CYPERACEAE

188- ***Carex divisa*** Huds.: Mo, Th, Saarad صارد
189- ***Cyperus alopecuroides*** Rottb.: Bi, GH, Samaar helw, سمار حلو
Syns. *Cyperus dives* Delile
Cyperus fastigiatus Forssk.
Juncellus alopecuroides (Rottb.) C.B. Clarke in Hook.
190- ***Cyperus articulatus*** L. : Bi, GH, Boot, بوط
Syn. *Cyperus niloticus* Forssk.
191- ***Cyperus capitatus*** Vand.: Bi, GH, Se'd سعد
192- ***Cyperus difformis*** L. : Bi, Th, Se'd سعد
193- ***Cyperus laevigatus*** L. : Bi, GH, Borbeit, بربيط
194- ***Cyperus rotundus*** L. : Bi, GH, Se'd, سعد
195- ***Scirpus holoschoenus*** L.: Bi, GH, Dee, دييس
Syns. *Scirpus romanus* L.
Scirpus australis Murray in L.
Holoschoenus vulgaris link
Scirpus holoschoenus L. var. *australis* (Murray) W.D.J. Koch
196- ***Scirpus litoralis*** Schrad.: Bi, GH, Se'ed سعد
Syn. *Schoenoplectus litoralis* (Schrad.) Palla
197- ***Scirpus maritimus*** L. : Bi, GH, Dees, ديس
Syns. *Scirpus maritimus* var. *tuberosus* (Desf.) Roem. & Schult.
Scirpus tuberosus Desf.

4.1.2. Species Distribution

The flora and vegetation of Lake Burullus had been studied as a part of north Nile Delta by Al-Sodany (1992) and (1998), Shaltout *et al.* (1995) and El-Kady *et al.* (2000). The number of the recorded species in Burullus Wetland, as estimated by Shaltout and Al-Sodany (2000), was 197 species: 100 annuals and 97 perennials, including 12 hydrophytes. These species belong to 44 families and 139 genera. The grasses have the highest contribution to the total flora (18.1%), followed by composites (13.6%), chenopods (10.1%), legumes (7.0%) and crucifers (6.0%). Twelve species were recorded in ≥ 75% of the prevailing habitats (Table 4.1 and 4.2): seven perennials (*Phragmites australis, Arthrocnemum macrostachyum*, *Halocnemum strobilaceum*, *Sarcocornia fruticosa*, *Suaeda vera, Cynodon dactylon* and *Tamarix nilotica*) and five annuals (*Salsola kali, Senecio glaucus* subsp. *coronopif olius, Mesembryanthemum nodiflorum, Polypogon monspeliensis* and *Spergularia marina*). The following is a brief summary of species distributions among habitats:

Table 4.1. **Perennial species recorded in the main habitats of Burullus Wetland. The values are the presence percentages. The life forms are: Ph: phanerophytes, Ch: chamaephytes, H: hemicryptophytes, GH: geophytes-helophytes, HH: hydrophytes, Th: therophytes and P: parasites. The floristic categories are ME: Mediterranian, COSM: Cosmopolitan, SA: Saharo-Arabian, TR: Tropical, SU: Sudanian, MA: Malysian, ES: Euro-Sibarian, IT: Irano-Turanian, GC: Guineo-congolese and IN: Indian. The habitats are: SM: salt marshes, SS: sand formations, LG: lake cuts, TD: terraces, SD: slopes, ED: water edges and OD: open water zones of the drains, LS: lake shores, LO: open water of the lake and IS: islets.**

Species	Life form	Floristic category	Habitat										Total
			SM	SS	LG	TD	SD	ED	OD	LS	LO	IS	
Terresterials													
Phragmites australis	GH	COSM	41	27	20	24	52	44	31	69	93	74	**10**
Arthrocnemum macrostachyum	Ch	ME+SA	85	91	100	46	56	24	6	88		72	**9**
Sarcocornia fruticosa	Ch	SA	30	8	60	33	52	40	13	63		46	**9**
Suaeda vera	Ch	ME+ES+SA	30	8	60	52	52	16	13	19		32	**9**
Tamarix nilotica	Ph	SA+SU	41	15	10	9	8	8	19	56		19	**9**
Halocnemum strobilaceum	Ch	ME+SA+IT	56	91	90	15	24	4		13		22	**8**
Cynodon dactylon	GH	COSM	11	8	10	15	16	20		19		11	**8**
Zygophyllum album var. *album*	Ch	ME+SA	26	46	50	15	12	12		6			**7**
Inula crithmoides	Ch	SA	22	8		9	4	4		25		59	**7**
Juncus acutus	GH	ME+ES+IT	44	8	40	6		8		63		57	**7**
Polygonum equisetiforme	GH	ME+IT	7		20	33	20	28		31			**6**
Suaeda pruinosa	Ch	ME+SA	15		10	15	8			31		2	**6**
Aster squamatus	Ch	TR		15		6	20	24		19		2	**6**
Cressa cretica	H	ME+IT+TR	22	15	50	6						2	**5**
Juncus rigidus	GH	ME+SA+IT	15	8	10					6		39	**5**
Cyperus rotundus	GH	ME+IT+TR	4		20	3		8		6			**5**
Persicaria salicifolia	GH	COSM				6	8	12		6		4	**5**
Typha domingensis	GH	ME+IT				3		4		31	60	33	**5**
Paspalidium geminatum	GH	TR				3	4	4		13		2	**5**
Echinochloa stagnina	GH	TR						8	13	13	7	4	**5**
Atriplex canescens	Ch	MA	4			12	20	8					**4**
Launaea nudicaulis	H	SA+IT+SU		18	60	9				6			**4**

Table 4.1. Cont. 1.

Species	Life form	Floristic category	Habitat										Total
			SM	SS	LG	TD	SD	ED	OD	LS	LO	IS	
Phyla nodiflora	H	ME+IT+TR				3	12	16		6			**4**
Atriplex nummularia	Ch	TR				6	12	4		25			**4**
Saccharum spontaneum	GH	ME+SA+IT+TR				3		4		13		2	**4**
Suaeda maritima	Ch	COSM				3		8		6		13	**4**
Cynanchum acutum	Ph	ME+IT		8				4				4	**3**
Alhagi graecorum	Ch	ME+SA+IT+SU	7	8	10								**3**
Cyperus alopecuroides	GH	TR	4							13	27		**3**
Convolvulus arvensis	H	TR		8		3	8						**3**
Atriplex halimus	Ph	ME+SA				3	4					6	**3**
Scirpus maritimus	GH	COSM						8		25		17	**3**
Centaurea calcitrapa	Ch	ME+ES				6	8	4					**3**
Paspalum distichum	GH	COSM				3		4		13			**3**
Atriplex portulacoides	Ch	ME+ES+IT				3				6		61	**3**
Cyperus articulatus	GH	TR						4		6		2	**3**
Scirpus litoralis	GH	ME+IT+TR				3				6		19	**3**
Vossia cuspidata	GH							4		6		2	**3**
Limonium pruinosum	GH	ME	7							13			**2**
Aeluropus lagopoides	GH	ME+SA+IT	19									26	**2**
Aeluropus littoralis	GH	ME+IT	4									2	**2**
Limoniastrum monpetalum	Ch	ME	7									2	**2**
Cynomorium coccineum	GH	ME+SA+IT	4									17	**2**
Atriplex leucoclada	Ch	SA+IT			10	3							**2**
Agathophora alopecuroides	Ch	SA				3				19			**2**
Pluchea dioscoridis	Ph	SA+SU				3		4					**2**
Centaurea pumilio	Ch	ME				6						13	**2**
Sphaeranthus suaveolens	H						8	4					**2**
Mentha longifolia	GH	COSM					4	8					**2**

Table 4.1. Cont. 2.

Species	Life form	Floristic category	Habitat										Total
			SM	SS	LG	TD	SD	ED	OD	LS	LO	IS	
Juncus subulatus	GH	ME+SA+IT								31		11	**2**
Ipomoea carnea	H	ME+IT					4	4					**2**
Tamarix tetragyna	Ph	ME+SA								6		2	**2**
Alternanthera sessilis	GH	ME+IT+TR	4										**1**
Echinops spinosissimus	H	ME+SA	4										**1**
Frankenia revoluta	H	ME+IT+EU	7										**1**
Imperata cylindrica	GH	ME+SA+IT	4										**1**
Ricinus communis	Ph		7										**1**
Scirpus holoschoenus	GH	ME+ES+IT	7										**1**
Tamarix aphylla	Ph	SA+SU	15										**1**
Cistanche phelypaea	p	ME+SA		8									**1**
Convolvulus lanatus	Ph	SA		8									**1**
Cornulaca monacantha	Ch	SA+SU+IN		8									**1**
Cyperus capitatus	GH	ME+GC		8									**1**
Elymus farctus	GH	ME		8									**1**
Fagonia arabica	Ch	ES		8									**1**
Heliotropium curassavicum	Ch	TR		8									**1**
Orobanche cernua	P	ME+SA+IT		8									**1**
Panicum turgidum	GH	SA+SU		8									**1**
Silene succulenta	H	ME		8									**1**
Polypogon viridis	H	ME+IT+EU				6							**1**
Salix tetrasperma	Ph	ME+ES+IT				3							**1**
Silybum marianum	H	ME+ES+IT				3							**1**
Plantago major	H	COSM					4						**1**
Clerodendrum acerbianum	Ch							4					**1**
Sida alba	H	SU						8					**1**
Orobanche ramosa var. *schweinfurthii*	P	ME+IT								6			**1**
Persicaria senegalensis	GH	ME+TR								6			**1**
Vigna luteola	Ch	SU+TR								6			**1**
Allium roseum	GH	SA										4	**1**

Table 4.1. Cont. 3.

Species	Life form	Floristic category	Habitat										Total
			SM	SS	LG	TD	SD	ED	OD	LS	LO	IS	
Asparagus stipularis	GH	ME+SA										15	**1**
Cyperus laevigatus	GH	ME+SA+IT										2	**1**
Lycium schweinfurthii	Ph	ME										17	**1**
Pancratium maritimum	GH	ME										7	**1**
Phoenix dactylifera	Ph	SA+SU										2	**1**
Urginea undulata	GH	ME+SA										2	**1**
Hydrophytes													
Potamogeton pectinatus	HH	COSM						4	13	6	93	15	**5**
Eichhornia crassipes	HH	TR						16	31	13	40	9	**5**
Ceratophyllum demersum	HH	COSM						4	31		40	17	**4**
Lemna perpusilla	HH	COSM							6	6	7	2	**4**
Ludwigia stolonifera	HH	ME+TR						4		13	13	4	**4**
Lemna gibba	HH	COSM						8	19				**2**
Potamogeton crispus	HH	COSM						8	19				**2**
Azolla filiculoides	HH	TR							63		13		**2**
Wolffia hyaline	HH	COSM								6	7		**2**
Ceratophyllum submersum	HH	ME+ES+IT									7		**1**
Najas marina v. armata	HH	COSM									20		**1**
Najas minor	HH	ME+ES+IT									7		**1**
Total species			**30**	**27**	**17**	**37**	**24**	**40**	**13**	**43**	**14**	**45**	**97**

Table 4.2. **Annual species recorded in the main habitats of Burullus Wetland. The values are the presence percentages. The floristic categories are ME: Mediterranian, COSM: Cosmopolitan, SA: Saharo-Arabian, TR: Tropical, SU: Sudanian, MA: Malysian, ES: Euro-Sibarian, IT: Irano-Turanian, GC: Guineo-congolese and IN: Indian. *: indicates the endemic species. The habitats are: SM: salt marshes, SS: sand formations, LG: lake cuts, TD: terraces, SD: slopes, ED: water edges and OD: open water zones of the drains, LS: lake shores, LO: open water of the lake and IS: islets.**

Species	Floristic category	Habitat										Total
		SM	SS	LG	TD	SD	ED	OD	LS	LO	IS	
Salsola kali	COSM	82	100	100	49	44	16	6	31			**8**
Senecio glaucus subsp. *coronopifolius*	ME+SA+IT	22	27	70	67	48	4		13		2	**8**
Mesembryanthemum nodiflorum	ME+ES+SA	26	8	20	39	8	12		25		11	**8**
Polypogon monspeliensis	COSM	4	8	20	21	28	4		44		18	**8**
Spergularia marina	ME+ES+IT	22	15	50	12	24	16		63		30	**8**
Chenopodium album	COSM		15	10	6	4	8		6		4	**7**
Mesembryanthemum crystallinum	ME+ES	19	18	20	15	8					2	**6**
Sphenopus divaricatus	ME+SA+IT	7	8		9	12			13		4	**6**
Rumex dentatus	ME+ES+IT				15	36	36		31	13	13	**6**
Chenopodium murale	COSM	4			27	24			6		7	**5**
Malva parviflora	ME+IT	19			27	24			13		11	**5**
Conyza bonariensis	ME+MA		15		6	4	4		6			**5**
Chenopodium ambrosioides	COSM				6	20	16		38		2	**5**
Chenopodium opulifolium	ME+ES+IT				3	4	4		6		7	**5**
Ranunculus sceleratus	ME+ES+IT				6	4	16			7	11	**5**
Trigonella stellata	SA+IT	11	8	10					6			**4**
Sonchus oleraceus	COSM				33	44	4				2	**4**
Anethum graveolens	SU	4			3	4						**3**
Cichorium endivia subsp. *pumilum*	ME+IT	4			9	4						**3**
Cutandia memphitica	ME+SA+IT	11	8								2	**3**
Hordeum vulgare	ME+IT	4			6	4						**3**
Echinochloa crusgalli	ME+ES+IT				6		4		13			**3**
Reichardia tingitana	SA+IT		27	10							4	**3**
Ifloga spicata	ME+SA		18		3						9	**3**
Hordeum marinum	ME+ES+IT				6	4					7	**3**

Table 4.2. Cont. 1.

Species	Floristic category	Habitat										Total
		SM	SS	LG	TD	SD	ED	OD	LS	LO	IS	
Hordeum murinum subsp. *leporinum*	ME+IT				21	16					2	**3**
Medicago polymorpha	COSM				3	4					15	**3**
Urospermum picroides	ME+IT				3	4					2	**3**
Melilotus indicus	ME+SA+IT				9	12			6			**3**
Sonchus asper	ME+IT				3	4			13			**3**
Chenopodium glaucum	ME+ES+IT	15		10								**2**
Eruca sativa	ME+SA+IT+ES	4			3							**2**
Lotus halophilus	ME+SA		8								7	**2**
Schismus barbatus	ME+SA+IT		8								15	**2**
Amaranthus viridis	COSM			10	33							**2**
Avena fatua	COSM				6	4						**2**
Bassia indica	IT+SU				6	4						**2**
Beta vulgaris	ME+ES+IT				24	20						**2**
Carduus pynocephalus	ME+IT				6	4						**2**
Cyperus difformis	COSM				3	4						**2**
Lolium perenne	ME+ES+IT				6	12						**2**
Lolium temulentum	ME+ES+IT				6	8						**2**
Lotus arabicus	TR				6	8						**2**
Parapholis marginata	ME				6	4						**2**
Senecio vulgaris	ME+ES+IT				6	8						**2**
Trigonella laciniata	SA+SU				12	16						**2**
Emex spinosa	ME+SA				3						7	**2**
Ammi visnaga	ME+IT				3		4					**2**
Lolium multiflorum	ME+IT+EU				3				6			**2**
Phalaris minor	ME+IT				6				6			**2**
Anagallis arvensis	ME+ES+IT					4					2	**2**
Eclipta alba	TR+MA						4		6			**2**
Carex divisa	ME+ES+IT	4										**1**

Table 4.2. Cont. 2.

Species	Floristic category	Habitat										Total
		SM	SS	LG	TD	SD	ED	OD	LS	LO	IS	
Amaranthus lividus	TR	11										1
Astragalus peregrinus	SA	4										1
Frankenia pulverulenta	ME+ES+IT	4										1
Rapistrum rugosum	ME+ES+IT	4										1
Bromus catharticus	ME+ES+IT+MA		8									1
Cakile maritime	ME+IT		8									1
Orobanche crenata	ME+IT		15									1
Rumex pictus	ME+SA			40								1
Brassica rapa	COSM				3							1
Coronopus didymus	COSM				3							1
Coronopus squamatus	ME+ES+IT				3							1
Juncus bufonius	COSM				6							1
Raphanus raphanistrum	ME+ES				9							1
Trifolium alexandrinum	ME				3							1
Amaranthus hybridus	TR					4						1
Coriandrum sativum	ME+IT					4						1
Gnaphalium luteo-album	TR					4						1
Lathyrus marmoratus	ME					4						1
Phalaris paradoxa	ME+IT+EU					4						1
Sisymbrium irio	COSM					4						1
Sonchus macrocarpus	Endimic					4						1
Trifolium resupinatum	ME+ES+IT					8						1
Medicago intertexa v. *ciliaris*	ME+ES						4					1
Rorippa palustris	ME+ES						4					1
Setaria verticillata	COSM						8					1
Setaria viridis	ME+ES+IT						4					1
Chrysanthemum coronarium	ME								6			1
Poa annua	ME+ES+IT								6			1
Adonis dentate	ME+SA+IT										4	1
Astragalus boeticus	ME										2	1

Table 4.2. Cont. 3.

Species	Floristic category	Habitat										Total
		SM	SS	LG	TD	SD	ED	OD	LS	LO	IS	
Brassica tournefortii	ME+SA+IT										2	**1**
Calendula arvensis	ME+ES+IT+SA										2	**1**
Cutandia dichtoma	SA+IT										2	**1**
Echinochloa colona	ME+IT+TR										2	**1**
Erodium laciniatum	ME										2	**1**
Euphorbia peplis	ME+ES+IT										11	**1**
Filago desertorum	SA+IT										4	**1**
Launaea capitata	SA+SU										11	**1**
Lobularia arabica	SA										9	**1**
Paronychia arabica	ME+SA+SU										7	**1**
Parapholis incurva	ME+ES+IT										2	**1**
Portulaca oleracea	COSM										2	**1**
Ranunculus marginatus	SA+IT										2	**1**
Silene villosa	SA										7	**1**
Sinapis arvensis subsp. *allionii*	SA										7	**1**
Spergula fallax	ME+SA+SU										2	**1**
Sporopolus pungens	ME+ES										7	**1**
Total Species		**21**	**18**	**12**	**50**	**45**	**19**	**1**	**22**	**2**	**44**	**100**

4.1.2.1. Salt marshes

A total of 51 species were recorded in this habitat: 21 annuals and 30 perennials. The unique species (one of the criteria that is used in assessing the natural reserves) to this habitat are (Table 4.3): *Alternanthera sessilis*, *Echinops spinosissimus, Frankenia revoluta*, *Imperata cylindrica, Ricinus communis, Scirpus holoschoenus, Tamarix aphylla, Carex divisa, Astragalus peregrinus, Amaranthus lividus*, *Frankenia pulverulenta* and *Rapistrum rugosum*. The common species (P ≥ 40%) are: *Arthrocnemum macrostachyum*, *Halocnemum strobilaceum, Juncus acutus*, *Phragmites australis, Tamarix nilotica* and *Salsola kali*. The rare species (P ≤ 5%) are: *Cyperus rotundus, Atriplex canescens, Cyperus alopecuroides, Cynomorium coccineum, Polypogon monspeliensis, Chenopodium murale* and *Sonchus oleraceus*.

Table 4.3. **Unique species to each of the main habitats in Lake Burullus area.**

Habitat	Annual	Perennial	Total
Salt marshes	5	7	12
Sand formations	2	10	12
Lake cuts	1	0	1
Terraces of the drains	6	3	9
Slopes of the drains	8	1	9
Water-edges of the drains	4	2	6
Open-water of the drains	0	0	0
Lake shores	2	3	5
Open-water of the lake	0	3	3
Lake islets	19	7	26
Total	**47**	**36**	**83**

4.1.2.2. Sand formations

A total of 45 species were recorded in this habitat: 18 annuals and 27 perennials. The unique species are: *Cistanche phelypaea, Convolvulus lanatus, Cornulaca monacantha, Cyperus capitata, Elymus farctus, Heliotropium curassavicum, Orobanche cernua, Panicum turgidum, Silene succulenta, Bromus catharticus, Cakile maritima* and *Fagonia arabica*. The common species are: *Arthrocnemum macrostachyum, Halocnemum strobilaceum, Zygophyllum album* and *Salsola kali*. The rare species (P ≤ 9%) are: *Cynodon dactylon, Cressa cretica, Cynanchum acutum, Alhagi graecorum* and *Sphenopus divaricatus*.

4.1.2.3. Lake cuts

A total of 29 species were recorded in this area: 12 annuals and 17 perennials. Only *Rumex pictus* is the unique species in this habitat. The common species are: *Arthrocnemum macrostachyum, Halocnemum strobilaceum, Sarcocornia fruticosa, Suaeda vera, Zygophyllum album, Juncus rigidus, Launaea nudicaulis, Salsola kali* and *Spergularia marina*. The rare species are*: Tamarix nilotica, Cynodon dactylon, Suaeda pruinosa, Juncus rigidus, Alhagi graecorum, Chenopodium album, Trigonella stellata, Reichardia tingitana* and *Amaranthus viridis.*

4.1.2.4. Terraces of the drains

A total of 87 species were recorded in this habitat: 50 annuals and 37 perennials. The unique species are: *Polypogon viridis, Salix tetrasperma, Silybum marianum, Brassica rapa, Coronopus didymus, Coronopus squamatus, Juncus bufonius, Raphanus raphanistrum* and *Trifolium alexandrinum*. The common species are: *Arthrocnemum macrostachyum, Suaeda vera, Salsola kali,* and *Senecio glaucus* subsp. *coronopifolius*. The rare species are: *Cyperus rotundus, Typha domingensis, Phyla nodiflora, Saccharum spontaneum, Atriplex portulacoides, Ifloga spicata, Cyperus difformis* and *Emex spinosa.*

4.1.2.5. Slopes of the drains

A total of 69 species were recorded in this habitat: 45 annuals and 24 perennials. The unique species are: *Plantago major, Amaranthus hybridus, Coriandrum sativum, Gnaphalium luteo-album, Lathyrus marmoratus, Phalaris paradoxa, Sisymbrium irio, Sonchus macrocarpus* and *Trifolium resupinatum*. The common species are: *Phragmites australis, Arthrocnemum macrostachyum, Sarcocornia fruticosa, Suaeda vera, Salsola kali, Senecio glaucus* subsp. *coronopifolius* and *Sonchus oleraceus*. The rare species are*: Paspalidium geminatum, Atriplex halimus, Ipomoea carnea, Ranunculus sceleratus, Cichorium endivia* subsp. *pumilum, Hordeum marinum, Medicago polymorpha* and *Anagallis arvensis*.

4.1.2.6. Water-edges of the drains

A total of 59 species were recorded: 19 annuals and 40 perennials including 6 hydrophytes. The unique species are: *Clerodendrum acerbianum, Sida alba, Medicago intertexa* var. *ciliaris, Rorippa palustris, Setaria verticillata* and *Setaria viridis*. The common species are: *Phragmites australis, Sarcocornia fruticosa* and *Azolla filiculoides*. The rare species are: *Halocnemum strobilaceum, Inula*

crithmoides, Cynanchum acutum, Suaeda maritima, Centaurea calcitrapa, Sphaeranthus suaveolens, Tamarix tetragyna and *Ammi visnaga.*

4.1.2.7. Open-water of the drains

A total of 14 species were recorded in this habitat. The common species are: *Phragmites australis, Eichhornia crassipes, Ceratophyllum demersum, Azolla filiculoides* and *Echinochloa stagnina.* The rare species are: *Arthrocnemum macrostachyum, Sarcocornia fruticosa, Lemna perpusilla, Potamogeton crispus* and *Salsola kali.*

4.1.2.8. Lake shores

a total of 65 species were recorded in this habitat: 22 annuals and 43 perennials including 5 hydrophytes. The unique species are: *Orobanche ramosa* var. *schweinfurthii, Persicaria senegalensis, Vigna luteola, Chrysanthemum coronarium* and *Poa annua.* The common species are: *Phragmites australis, Arthrocnemum macrostachyum, Sarcocornia fruticosa, Tamarix nilotica, Juncus acutus, Spergularia marina* and *Polypogon monspeliensis.* The rare species are: *Zygophyllum album, Cyperus rotundus, Persicaria salicifolia, Phyla nodiflora, Cyperus articulatus, Conyza bonariensis, Melilotus indicus, Potamogeton pectinatus, Eichhornia crassipes, Lemna perpusilla, Ludwigia stolonifera* and *Wolffia hyalina.*

4.1.2.9. Open-water of the lake

Sixteen perennial species were recorded in this habitat including 10 hydrophytes. The unique species to this habitat are: *Ceratophyllum submersum, Najas marina* var. *armata* and *Najas minor.* The common species are: *Phragmites australis, Typha domingensis, Potamogeton pectinatus, Eichhornia crassipes* and *Ceratophyllum demersum.* The rare species are: *Cyperus alopecuroides, Echinochloa stagnina, Lemna perpusila, Ludwigia stolonifera, Wolffia hyalina* and *Potamogeton crispus*

4.1.2.10. Lake islets

A total of 89 species were recorded in this type of habitat: 45 annuals and 44 perennials including 5 hydrophytes (see Khedr and Lovett-Doust 2000). The unique species to this habitat are: *Allium roseum, Asparagus stipularis, Cyperus laevigatus, Lycium schweinfurthii, Pancratium maritimum, Phoenix dactylifera, Urginea undulata, Adonis dentata, Astragalus boeticus, Brassica tournefortii, Calendula aegyptiaca, Cutandia dichtoma, Echinochloa colona, Erodium laciniatum, Euphorbia peplis, Filago desertorum, Launaea capitata, Lobularia arabica, Paronychia arabica, Parapholis incurva, Portulaca oleracea, Ranunculus marginatus, Silene villosa, Spergula fallax, Sinapis arvensis* subsp.

allionii and *Sporpolus pungens*. The common species are: *Phragmites australis, Arthrocnemum macrostachyum, Sarcocornia fruticosa, Inula crithmoides* and *Juncus acutus*. The rare species are: *Suaeda pruinosa, Cressa cretica, Aster squamatus, Saccharum spontaneum, Cyperus articulatus, Limoniastrum monpetalum, Tamarix tetragyna, Mesembryanthemum crystallinum, Anagallis arvensis, Potamogeton pectinatus, Eichhornia crassipes, Ceratophyllum demersum* and *Lemna perpusilla*.

The total number of species in the lake islets varies between 5 species in El-Beyaku, Al-Maqati and Ez-Zawyah islets to 63 species in El-Kawm Al-Akhdar islet (Table 4.4). Az-Zanaqah islet has the highest species richness (15.5 species / stand), followed by Al-Kawm Al-Akhdar islet (14.2 species / stand), while Az-Zawyah has the lowest species richness (4.5 species / stand). Four habitat types occur in Al-Kawm Al-Akhdar and Doshimi islets (salt marshes, sand formations, ponds and gravel sand formations). Al-Kawm Al-Akhdar has also the highest number of unique species (20 out of 26 species in the all islets) and plant communities (7 out of 13 communities in the whole region of Burullus Wetland).

4.1.3. Life Forms and Species Diversity

The life form spectra of the vegetation in the Burullus Wetland indicated that, therophytes had the highest contribution in all habitats, except the open water zones of drains and lake. This life form ranges between 7.1 % in the open-water zone and 65.2% along the slopes of drains. Regarding the perennial life forms, geophytes-helophytes were the most frequent in the study area with a total relative value of 17.8%, while phanerophytes and parasites were the lowest with a total relative value of 5.6% and 2.0%, respectively. The open water zones of the drains and the lake were characterized by hydrophytes (50% and 62.5%, respectively) which represent 6.1% of the total species (Table 4.5, Fig. 4.1).

Regarding species diversity (see Wittaker 1972, Pielou 1975, Maguran 1988), the drain slopes and lake islets had the highest species richness (13.4 and 11.3 species/stand, respectively), while the open water of the lake had the lowest species richness (2.5 species/stand) and relative evenness (H' = 1.02), but the highest relative concentration of dominance (C = 0.12). The open water of the drains also had low relative evenness (1.05) and high relative concentration of dominance (C = 0.11) (Table 4.6, Fig. 4.2).

Table 4.4. **Species richness and habitat types in the islets of Lake Burullus. The plant communities are: Art: *Arthrocnemum macrostachyum*, Jun: *Juncus acutus*, Phr: *Phragmites australis*, Sua: *Suaeda pruinosa*, Pot: *Potamogeton pectinatus*, Typ: *Typha domingensis*, Cer: *Ceratophyllum demersum*, Inu: *Inula crithmoides*, and Hal: *Halocnemum strobilaceum.* The habitat types are: I: salt marshes, II: sand formations, III: ponds, IV: muddy lands, V: gravel sand formations and VI: calcareous soils.**

Lake islets	Taxonomic diversity			Species richness	Species turnover	Unique species	Plant communities	Habitat type
	Family	Genus	Species					
Dechimi	13	20	24	11.5	2.1	0	Art-Jun (1), Phr-Sua (2), Pot (7)	I, II, III, V
Ad-Dakhlah	12	18	20	11.3	1.8	1	Pot (7), Phr (10), Phr-Pot (13)	IV
Al-Basharush	11	16	19	14.0	1.4	0	Phr -Art (3)	I
Farash El-Toob	6	9	13	8.5	1.5	1	Phr -Art (3)	I
Az-Zanqah	11	19	22	15.5	1.4	2	Phr -Art (3)	I
El-Ghariq Al-Qibli	7	10	13	11.0	1.2	0	Phr -Art (3), Typ-Cer (12), Phr-Pot (13)	I, IV
El-Kawm Al-Akhdar	24	56	63	14.2	4.4	20	Art-Jun (1), Phr -Art (3), Sua-Inu (4), Sar (6), Pot (7) , Hal (8), Phr-Pot (11)	I, II, III, V
Ibsak	8	11	17	6.5	2.6	2	Phr -Art (3)	I
Ash-Shishah	9	13	16	10.0	1.6	0	Phr -Art (3)	I
Sinjar	8	13	16	12.0	1.3	0	Art-Jun (1)	I
El-Kodyah	9	13	15	9.4	1.6	0	Art-Jun (1), Phr -Art (3)	I, VI
El-Beyako	3	5	6	6.0	1.0	0	Phr -Art (3)	I
Al-Maqati	3	6	6	6.0	1.0	0	Art-Jun (1)	I
Az-Zawyah	2	6	6	4.5	1.3	0	Phr -Art (3)	I
Al-Mahjarh	4	8	8	6.0	1.3	0	Phr -Art (3)	I, III
Bat El-kawm	4	8	8	8.0	1.0	0	Art-Jun (1)	I, VI
Total	**30**	**71**	**89**	**11.0**	**8.1**	**26**	**13**	**6**

Table 4.5. **Life form spectra of the recorded species in the main habitats of Burullus Wetland. A: absolute value, R: relative value. The habitats are: SM: salt marshes, SS: sand formations, LG: lake cuts, TD: terraces, SD: slopes, ED: water edges and OD: open water zones of the drains, LS: lake shores and LO: open water of the lake.**

Life Form		Habitat										Total
		SM	SS	LG	TD	SD	ED	OD	LS	LO	IS	
Phanerophytes	A	3	3	1	4	2	3	1	2	--	6	11
	R	5.9	6.7	3.4	4.6	2.9	5.1	7.1	3.1	--	6.7	5.6
Chamaephytes	A	10	11	8	16	11	12	3	13	--	11	23
	R	19.6	24.4	27.6	18.4	15.9	20.3	21.4	20.0	---	12.4	11.7
Hemicrypto-phytes	A	3	4	2	6	5	4	--	2	--	1	12
	R	5.9	8.9	6.9	6.9	7.2	6.8	--	3.1	--	1.1	6.1
Geophytes-Helophytes	A	14	7	6	11	6	15	2	20	4	22	35
	R	27.5	15.6	20.7	12.6	8.7	25.4	14.3	30.8	25.0	24.7	17.8
Hydrophytes	A	--	--	--	--	--	6	7	5	10	5	12
	R	--	--	--	--	--	10.2	50.0	7.7	62.5	5.6	6.1
Parasites	A	--	2	--	--	--	--	--	1	--	--	4
	R	--	4.4	--	--	--	--	--	1.5	--	--	2.0
Therophytes	A	21	18	12	50	45	19	1	22	2	44	100
	R	41.2	40.0	41.4	57.5	65.2	32.2	7.1	33.8	12.5	49.4	50.8
Total		**51**	**45**	**29**	**87**	**69**	**59**	**14**	**65**	**16**	**89**	**197**

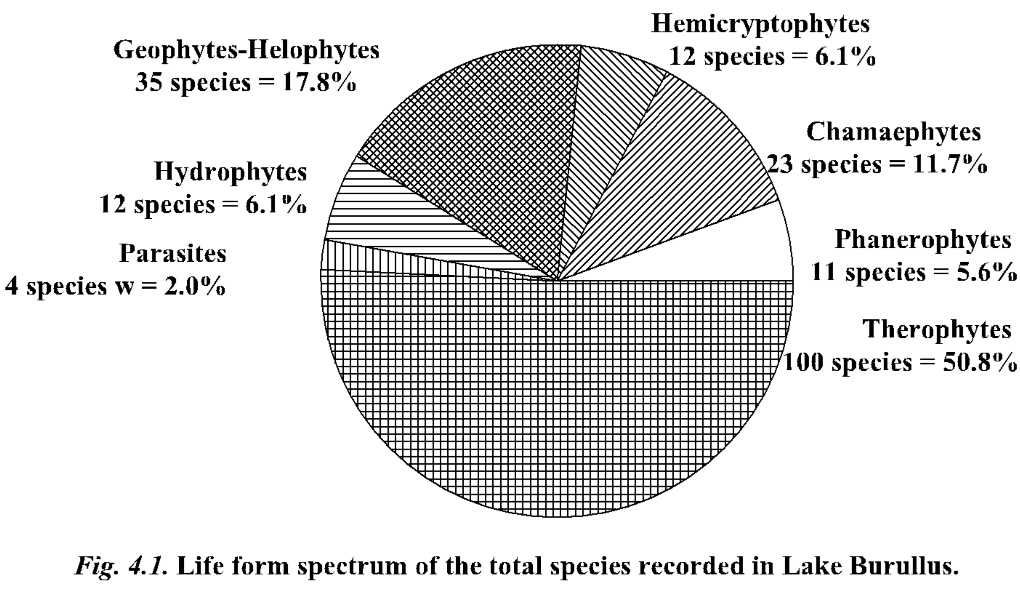


Fig. 4.1. **Life form spectrum of the total species recorded in Lake Burullus.**

Table 4.6. **Variation in some diversity indices calculated for the main habitats of Burullus Wetland. The habitats are: SM: salt marshes, SS: sand formations, LG: lake cuts, TD: terraces, SD: slopes, ED: water edges and OD: open water zones of the drains, LS: lake shores and LO: open water of the lake.**

Habitat	Total species	Species richness	Species turnover	Relative conc. of dominance	Relative evenness
SM	51	8.1	6.3	0.04	1.52
SS	45	3.2	14.1	0.05	1.47
LG	29	7.7	3.8	0.06	1.33
TD	87	11.0	7.9	0.03	1.73
SD	69	13.4	5.2	0.03	1.66
ED	59	7.8	7.6	0.03	1.63
OD	14	3.3	4.2	0.11	1.05
LS	65	9.4	6.9	0.03	1.65
LO	16	2.5	6.4	0.12	1.02
IS	88	11.3	7.8	0.03	1.68
Mean	52.3	7.8	7.0	0.05	1.47

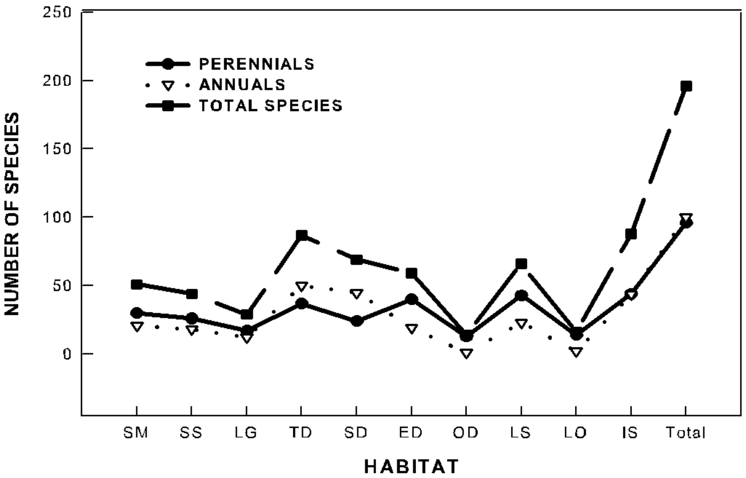


Fig. 4.2. **Variation in species richness of the main habitats in Burullus Wetland. The habitats are: SM: salt marshes, SS: sand formations, LG: lake cuts, TD: terraces, SD: slopes, ED: water-edges and OD: open-water of the drains LS: shores and LO: open-water of the lake and IS: lake islets.**

4.1.4. Phytogeography and Abundance

Regarding the global phytogeographical distribution (after Zohary 1966 and 1987, Feinburn-Dothan 1978 and 1986, Boulos 1999, 2000, 2002), the pluri-regional species were the highest (65 species = 33.0%), followed by bi-regional species (57 species = 28.9%). The mono-regionals (40 species = 20.3%) and cosmopolitans (31 species = 15.7%) were the lowest (Table 4.7). Thirteen of the mono-regional species are Mediterranean (6.6%): *Limonium pruinosum, Limoniastrum monopetalum, Centaurea pumilio, Elymus farctus, Silene succulenta, Lycium schweinfurthii, Pancratium maritimum, Parapholis marginata, Trifolium alexandrinum, Lathyrus marmoratus, Chrysanthemum coronarium, Astragalus boeticus* and *Erodium laciniatum.*

Regarding the national distribution (after Täckholm 1974), many of the recorded species in Burullus Wetland have a wide geographical distribution allover Egypt (Tables 4.8 and 4.9, Fig. 4.3 and 4.4). Twenty three perennials (23.7% of the total perennial species) and 32 annuals (32% of the total annual species) have a wide distribution (recorded in ≥ 8 regions out of 12 regions). The following 10 species were recorded in all the 12 regions: *Cressa cretica, Cynodon dactylon, Cyperus laevigatus, Cyperus rotundus, Juncus rigidus, Launaea nudicaulis, Phoenix dactylifera, Tamarix aphylla, Tamarix nilotica, Echinochloa colona.*

4.1.4.1. Endemic and rare species

In contrast with the cosmopolitans, there were 3 endemic species (Table 4.10): one perennial *(Zygophyllum album* subsp. *album*) and 2 annuals (*Sinapis arvensis* subsp. *allionii* and *Sonchus macrocarpus*). The perennial species that have a distribution restricted to Nile Delta are: *Ipomoea carnea, Vossia cuspidata* and *Ranunculus marginatus*. On the other hand, there are 18 rare perennials and 15 annuals (Table 4.10).

The analysis of species rarity in Burullus Wetland, based on the rarity forms of Rabinowitz (1981), indicated that 85 species which equivalent to 43% of the total flora in this region (44 perennials and 41 annuals) have low abundance, narrow habitat specificity and small geographical range (Tables 4.11, 4.12). On the other extreme, 19 species or 9.6 % of the total species (12 perennials and 7 annuals) have high abundance, wide habitat specificity and large geographical range (Fig. 4.5). The high number of species in the first category indicates the importance of the habitats of Burullus Wetland as refuges for these species such as (e.g. the groups of hydrophytes, halophytes and psammophytes).

Table 4.7. **Spectrum of the global distribution of the recorded species in Burullus Wetland. The regions are: ME: Mediterranean, COSM: cosmopolitan, SA: Saharo-Arabian, TR: tropical, SU: Sudanian, MA: Malysian, ES: Euro-Sibarian, IT: Irano-Turanian, GC: Guineo-congolese and IN: Indian.**

Floristic region	Number of species	Percentage
Endemics	**3**	**1.5**
Cosmopolitan	**31**	**15.7**
Monoregionals		0.0
ME	13	6.6
ES	1	0.5
SA	9	4.6
TR	14	7.1
SU	2	1.0
MA	1	0.5
Total	**40**	**20.3**
Bi-regionals		
ME+ES	6	3.0
ME+GC	1	0.5
ME+IT	18	9.1
ME+SA	13	6.6
ME+TR	2	1.0
ME+MA	1	0.5
IT+SU	1	0.5
SA+IT	6	3.0
SA+SU	7	3.6
SU+TR	1	0.5
TR+MA	1	0.5
Total	**57**	**28.9**
Pluri-regionals		
ME+ES+IT	28	14.2
ME+ES+SA	2	1.0
ME+IT+EU	4	2.0
ME+SA+IT	15	7.6
ME+IT+TR	6	3.0
ME+SA+SU	2	1.0
SA+IT+SU	1	0.5
SA+SU+IN	1	0.5
ME+ES+IT+SA	2	1.0
ME+SA+IT+SU	1	0.5
ME+SA+IT+TR	2	1.0
ME+ES+IT+MA	1	0.5
Total	**65**	**33.0**
Total species	**197**	

Table 4.8. **National geographical distribution of the perennial species recorded in Burullus Wetland (after Täckholm 1974). Nd: Nile Delta, Nv: Nile Valley, Nf: Nile Faiyum, O: Oases of the Libyan desert, Mm: western Mediterranean coastal region, Mp: eastern Mediterranean coastal region, Da: Arabian desert, Di: Isthmic desert, Dl: Libyan desert, R: Red sea coastal region, GE: Gebel Elba and surrounding mountains, and S: Sinai proper. cc: very common, c: common, r: rare and rr: very rare. T: total regions (out of 12).**

Species	Phytogeographical region												T
	Nd	Nv	Nf	O	Mm	Mp	Da	Di	Dl	R	GE	S	
TERRESTERIAL													
Cressa cretica	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	**12**
Cynodon dactylon	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	**12**
Cyperus laevigatus	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	**12**
Cyperus rotundus	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	**12**
Juncus rigidus	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	**12**
Launaea nudicaulis	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	**12**
Phoenix dactylifera	+	+	+	+	+	+	+	+	+	+	+	+	**12**
Tamarix aphylla	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	**12**
Tamarix nilotica	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	**12**
Aeluropus lagopoides	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc		cc	**11**
Alhagi graecorum	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc		cc	**11**
Imperata cylindrica	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc		cc	**11**
Phragmites australis	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc		cc	**11**
Polypogon viridis	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc		cc	**11**
Typha domingensis	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc		cc	**11**
Cistanche phelypaea	c	c		c	c	c	c	c	c	c		c	**10**
Panicum turgidum	cc	cc		cc		cc	cc	cc	cc	cc	cc	cc	**10**
Aster squamatus	c	c	c		r	r	r	r	r			r	**9**
Saccharum spontaneum	cc	cc	cc	cc	cc	cc		cc		cc		cc	**9**
Juncus acutus	c	c	c	c	c	c	c	c					**8**
Orobanche crenata	cc	cc	cc	cc	cc	cc	cc					cc	**8**
Zygophyllum album				cc	cc	cc	cc	cc	cc	cc		cc	**8**
Tamarix tetragyna	c	c	c	c	c		c	c		c			**8**
Arthrocnemum macrostachyum	c			c	c	c		c		c		c	**7**
Echinochloa stagnina	c	c	c	c	c	c	c						**7**
Echinops spinosissimus					cc	cc	cc	cc	cc	cc	cc	cc	**7**
Paspalidium geminatum	c	c	c	c	c	c		c					**7**
Phyla nodiflora	cc	cc	cc	cc	cc	cc		cc					**7**
Polygonum equisetiforme	cc	cc	cc	cc	cc	cc		cc					**7**
Scirpus litoralis	cc	cc	cc	cc	cc	cc		cc					**7**
Scirpus maritimus	cc	cc	cc	cc	cc	cc		cc					**7**
Suaeda vera	c				c	c	c			c	c	c	**7**
Pluchea dioscoridis	cc	cc	cc	cc	cc	cc	cc						**7**
Centaurea calcitrapa	cc	cc	cc	cc	cc	cc							**6**
Convolvulus arvensis	cc	cc	cc	cc	cc	cc							**6**
Convolvulus lanatus						cc	cc	cc	cc	cc		cc	**6**
Cornulaca monacantha					c		c	c	c	c		c	**6**
Cynanchum acutum	cc	cc	cc	cc	cc	cc							**6**
Cyperus alopecuroides	cc	cc	cc		cc	cc		cc					**6**
Halocnemum strobilaceum					c	cc		c		c		c	**6**
Inula crithmoides	c	c	c	c	c	c							**6**

Table 4.8. Cont. 1.

Species	Phytogeographical region												T
	Nd	**Nv**	**Nf**	**O**	**Mm**	**Mp**	**Da**	**Di**	**Dl**	**R**	**GE**	**S**	
Juncus subulatus	c	c	c	c	c	c		c					**6**
Sarcocornia fruticosa	c		c	c	c	c		c					**6**
Scirpus holoschoenus	r				r	r	r	r				r	**6**
Silybum marianum	cc	cc	cc	cc	cc			cc					**6**
Paspalum distichum	c	c			r	r		r				r	**6**
Asparagus stipularis				cc	cc	cc		cc				cc	**5**
Atriplex leucoclada				r	r	r		r				r	**5**
Cynomorium coccineum					r	r	r	r				r	**5**
Cyperus articulatus	c	c			c	c		c					**5**
Mentha longifolia	c	c	c	c								c	**5**
Persicaria salicifolia	cc	cc	cc		cc	cc							**5**
Plantago major	cc	cc		cc	cc							cc	**5**
Sida alba	c	c	c	c	c								**5**
Perisicaria senegalensis	cc	cc	cc		cc	cc							**5**
Atriplex nummularia	c			c	c				c				**4**
Suaeda maritima	c				c	c	c						**4**
Fagonia arabica				cc		cc	cc		cc				**4**
Frankenia revoluta				c	c	c		c					**4**
Limonium pruinosum					c	c		c				c	**4**
Orobanche cernua		r			r		r					r	**4**
Orobanche ramosa var. *schweinfurthii*	rr	rr	rr	rr									**4**
Sphaeranthus suaveolens	r				r	r	r						**4**
Salix tetrasperma	c	c			c			c					**4**
Cyperus capitatus		r			c	c		r					**4**
Alternanthera sessilis	c	c					c						**3**
Atriplex halimus					c		c	c					**3**
Suaeda pruinosa					r	r			r				**3**
Urginea undulata					c	c			c				**3**
Vigna luteola	c	c											**2**
Pancratium maritimum				c	c								**2**
Allium roseum					r	r							**2**
Atriplex portulacoides					c	c							**2**
Elymus farctus					c	c							**2**
Limoniastrum monpetalum					c	c							**2**
Silene succulenta					c	c							**2**
Atriplex canescens					r				r				**2**
Lycium schweinfurthii					rr				rr				**2**
Aeluropus littoralis					rr	rr							**2**
Ipomoea carnea	cc												**1**
Vossia cuspidata	+												**1**
Clerodendrum acerbianum		rr											**1**
Centaurea pumilio					c								**1**
Heliotropium curassavicum							rr						**1**
Agathophora alopecuroides								r					**1**
HYDROPHYTES													
Potamogeton crispus	cc	cc	cc	cc	cc	cc		cc	cc			cc	**9**
Potamogeton pectinatus	cc	cc	cc	cc	cc	cc		cc					**7**
Eichhornia crassipes	cc	cc	cc	cc	cc	cc							**6**

Table 4.8. Cont. 2.

Species	Phytogeographical region												T
	Nd	Nv	Nf	O	Mm	Mp	Da	Di	Dl	R	GE	S	
Pseudowolffia hyalina	c	c	c		c	c	c						**6**
Najas marina v. armata	c		c	c	c	c		c					**6**
Lemna gibba	cc	cc	cc	cc	cc								**5**
Ludwigia stolonifera	r			r	r	r		r					**5**
Najas minor	r			r	r	r		r					**5**
Ceratophyllum demersum	cc		cc			cc		cc					**4**
Lemna perpusilla	rr	rr		rr									**3**
Azolla filiculoides	cc												**1**
Ceratophyllum submersum	rr												**1**
Total species	**68**	**57**	**48**	**55**	**80**	**72**	**38**	**54**	**29**	**26**	**12**	**37**	**97**

***Table 4.9.* National geographical distribution of the annual species recorded in Lake Burullus area (after Täckholm 1974). Nd: Nile Delta, Nv: Nile Valley, Nf: Nile Faiyum, O: Oases of the Libyan desert, Mm: western Mediterranean coastal region, Mp: eastern Mediterranean coastal region, Da: Arabian desert, Di: Isthmic desert, D1: Libyan desert, R: Red sea coastal region, GE: Gebel Elba and surrounding mountains, and S: Sinai proper. cc: very common, c: common, r: rare and rr: very rare. +: species not recorded in Boulos 1995. T: total regions (out of 12).**

Species	Phytogeographical region												T
	Nd	Nv	Nf	O	Mm	Mp	Da	Di	DL	R	GE	S	
Echinochloa colona	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	**12**
Anagallis arvensis	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc		**11**
Chenopodium murale	cc	cc	cc	cc	cc	cc	cc	cc	cc		cc	cc	**11**
Malva parviflora	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc		cc	**11**
Polypogon monspeliensis	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc		cc	**11**
Reichardia tingitana	cc	cc	cc		cc	cc	cc	cc	cc	cc	cc	cc	**11**
Sonchus oleraceus	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc		cc	**11**
Frankenia pulverulenta	cc	cc	cc	cc	cc	cc	cc	cc	cc	cc		cc	**11**
Avena fatua	cc	cc	cc	cc	cc	cc	cc	cc	cc			c	**10**
Hordeum murinum subsp. *leporinum*	cc	cc	cc	cc	cc	cc	cc	cc	cc			cc	**10**
Launaea glomerata	cc			cc	cc	cc	cc	cc	cc	cc	cc	cc	**10**
Melilotus indicus	cc	cc	cc	cc	cc	cc	cc	cc	cc			cc	**10**
Parapholis marginata	r	r	r	r	cc	cc	r	r	r			r	**10**
Phalaris minor	c	c	c	c	c	c	c	c	c			c	**10**
Schismus barbatus	cc	cc		cc	cc	cc	cc	cc	cc	cc		cc	**10**
Eruca sativa	cc	cc	cc	cc	cc	cc	cc	cc				cc	**9**
Lolium perenne	cc	cc	cc	cc	cc	cc	cc	cc				cc	**9**
Senecio glaucus subsp. *coronopifolius*	cc	cc	cc	cc	cc	cc		cc		cc		cc	**9**
Setaria verticillata	cc	cc		cc	cc	cc	cc			cc	cc	cc	**9**
Sisymbrium irio	cc	cc	cc		cc		cc	cc		cc	cc	cc	**9**
Brassica tournefortii	cc	cc	cc	cc	cc	cc		cc				cc	**8**
Calendula aegyptiaca	cc		cc	cc	cc	cc	cc	cc				cc	**8**

Table 4.9. Cont. 1.

Species	Phytogeographical region												T
	Nd	Nv	Nf	O	Mm	Mp	Da	Di	DL	R	GE	S	
Conyza bonariensis	cc	cc	cc	cc	cc	cc		cc				cc	**8**
Cutandia memphitica				cc	cc	cc	cc	cc	cc	cc		cc	**8**
Emex spinosa	cc	cc	cc	cc	cc	cc	cc	cc					**8**
Gnaphalium luteo-album	cc	cc	cc	cc	cc		cc	cc				cc	**8**
Ifloga spicata					c	c	c	c	c	c	c	c	**8**
Lotus halophilus	cc		cc	cc	cc	cc	cc	cc	cc				**8**
Silene villosa					cc	cc	cc	cc	cc	cc	cc	cc	**8**
Trigonella laciniata	cc	cc	cc	cc	cc		cc	cc	cc				**8**
Trigonella stellata			c		c	c	c	c	c	c		c	**8**
Urospermum picroides	cc		cc	cc	cc		cc		cc		cc	cc	**8**
Beta vulgaris	cc	cc	cc	cc	cc			cc				cc	**7**
Carex divisa	c	c	c	c	c	c		c					**7**
Cyperus difformis	c	c	c	c	c	c						c	**7**
Echinochloa crusgalli	c	c	c	c	c	c			c				**7**
Filago desertorum					cc	cc	cc	cc	cc	cc		cc	**7**
Hordeum marinum	c	c	c	c	c	c			c				**7**
Juncus bufonius	c	c	c	c	c	c						c	**7**
Lolium multiflorum	cc	cc	cc	cc	cc	cc		cc					**7**
Portulaca oleracea	cc	cc	cc	cc	cc	cc						cc	**7**
Rumex dentatus	c	c	c	c	c	c	rr						**7**
Trifolium alexandrinum	cc	cc	cc	cc	cc	cc		cc					**7**
Trifolium resupinatum	cc	cc	cc	cc	cc	cc		cc					**7**
Orobanche crenata	cc	cc	cc	cc	cc	cc						cc	**7**
Chenopodium album	cc	cc		cc	cc			cc				cc	**6**
Chenopodium ambrosioides	cc	cc	cc	cc	cc	cc							**6**
Cichorium endivia subsp. *pumilum*	cc	cc	cc	cc	c							cc	**6**
Erodium laciniatum					r	r	r	r	r			r	**6**
Lolium temulentum	c			c	c	c		c				c	**6**
Medicago intertexa v. *ciliaris*	c	c	c	c	c	c							**6**
Spergula fallax			c		c		c	c	c		c		**6**
Poa annua	c	c	c		c		c						**6**
Bassia indica	c			c	c	c			c				**5**
Brassica rapa	c	c	c	c	c								**5**
Coronopus squamatus	c	c	c	c	c								**5**
Medicago polymorpha				cc	cc	cc	cc	cc					**5**
Paranchya arabica	c			c	r	r		c					**5**
Phalaris paradoxa	r	r	r		r			r					**5**
Salsola kali	c				c	c		c				c	**5**
Senecio vulgaris	cc	cc		cc	cc			cc					**5**
Setaria viridis	r	r						r			r	r	**5**
Sinapis arvensis subsp. *allionii*	c	c		c	c	c							**5**
Sonchus asper	c		r	r	r							r	**5**
Spergularia marina	cc	cc	cc		cc	cc							**5**
Chrysanthemum coronarium	r	r			cc	cc						r	**5**
Eclipta alba	cc	cc	cc	cc	cc								**5**
Adonis dentata					cc	cc		cc	cc				**4**
Amaranthus viridis	cc	cc			cc	cc							**4**
Astragalus peregrinus					c	c		c				c	**4**

Table 4.9. Cont. 2.

Species	Phytogeographical region												T
	Nd	Nv	Nf	O	Mm	Mp	Da	Di	DL	R	GE	S	
Carduus pynocephalus	c				c	c		c					4
Lathyrus marmoratus	r				cc	cc		r					4
Mesembryanthemum crystallinum	r				c	c	r						4
Ranunculus sceleratus	cc	cc	cc		cc								4
Sphenopus divaricatus				r	cc	cc		r					4
Cakile maritima	c				c	c		c					4
Ammi visnaga	c	c	c		c								4
Bromus catharicus	r	r			r				r				4
Rorippa palustris	c	c			c	c							4
Lotus arabicus	cc	cc		cc									3
Raphanus raphanistrum	rr	rr			rr								3
Amaranthus hybridus	c	c										c	3
Amaranthus lividus	r	r										r	3
Mesembryanthemum nodiflorum	r				c	c							3
Astragalus boeticus					c	c		c					3
Cutandia dichtoma					cc	cc		r					3
Lobularia arabica					c	c		c					3
Rumex pictus					c	c		c					3
Anethum graveolens	c	c											2
Chenopodium opulifolium	r	r											2
Coriandrum sativum	c	c											2
Coronopus didymus	r	r											2
Chenopodium glaucum	rr				rr								2
Sonchus macrocarpus	r				r								2
Sporopolus pungens				c	c								2
Euphorbia peplis					r	r							2
Parapholis incurva					r	r							2
Rapistrum rugosum					rr			rr					2
Ranunculus marginatus	r												1
Total species	**80**	**63**	**51**	**56**	**90**	**68**	**36**	**57**	**30**	**17**	**12**	**45**	**100**

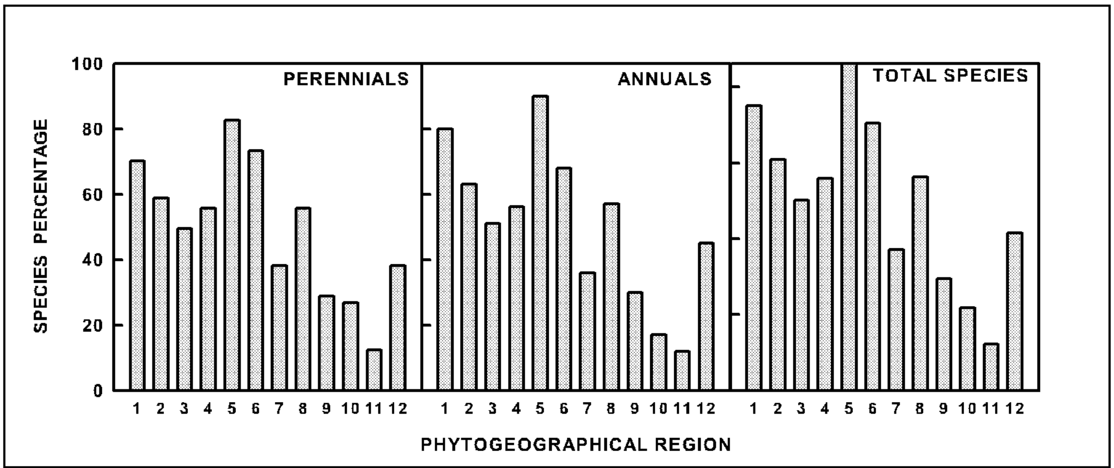


Fig. 4.3. **Species percentage of plants found in only one up to the 12 phytogeographical regions of Egypt.**

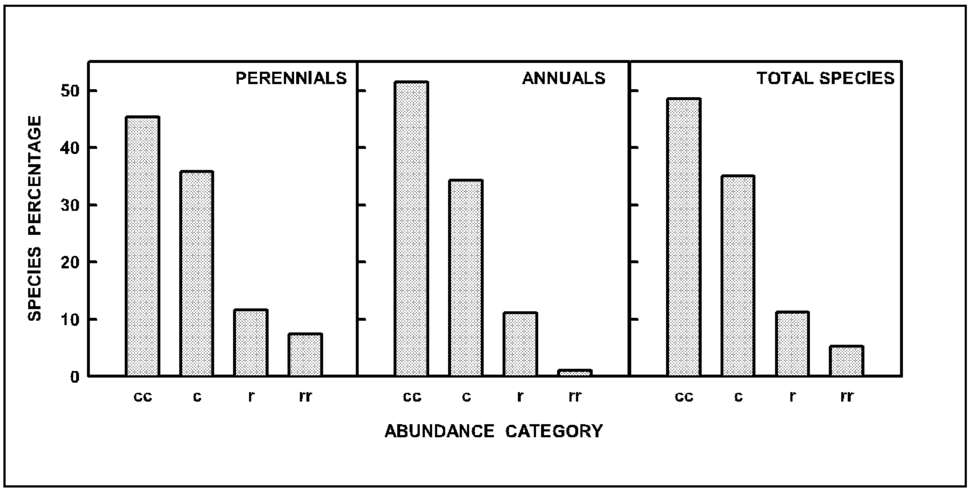


Fig. 4.4. **Species percentage of plants belong to the four abundance categories in at least one phytogeographical region. The abundance categories are: cc: very common, C; common, r: rare and rr: very rare.**

4.1.4.2. Noteworthy species

Egyptian neophytes are noteworthy species that differ from each other not only in time and way of their introduction but also in the degree of their establishment in various anthropogenic, seminatural or natural coenoses (for distribution of neophytes see Simpson 1932, Drar 1952, Walter 1971, El-Hadidi and Kosinova 1971, Täckholm and Boulos 1974, Hejny and Kosinova 1977, Zahran & Willis 1992, 2003). The following are 7 neophytic species that invaded some regions in Egypt including the Burullus Wetland:

1- *Paspalum distichum*. It is an alien species that rapidly spread in Nile Delta during the early decades of 20th century, it became naturalized lately in other parts of the Egyptian cultivated land and well established in anthropogenic and seminatural habitats (Hejny and Kosinova 1977).

2- *Ipomoea carnea.* It is an ornamental plant that collected in 1934 and deposited in the Herbarium of Agricultural Museum. It is a native to South America and was reported as naturalized species along the canals of Nile Delta (Boulos 1995). It grows in dense populations along river beds, banks, canals and other waterlogged areas and contributes to the mosquito nuisance. This plant propagates vegetatively by stems which are capable of rooting within a few days. The farmers use it as ornamental and hedge plant on the irrigation and drainage canals (see Eid 2002).

Table 4.10. **Endemic and rare species in Burullus Wetland.**

Species	Family	Location	Latitude (N)	Longitude (E)
Endemic species				
Sinapis arvensis subsp. *Allionii*	Brassicaceae	El-Kawm Al-khdar	31° 26' 98"	30° 49' 47"
Sonchus macrocarpus	Compsitae	Drain No. 8	31° 21' 56"	30° 48' 03"
Zygophyllum album subsp. *Album*	Zygophyllaceae	many locations	---	---
Perennial rare species				
Aeluropus litorallis	Poaceae	many locations	---	---
Agathophora alopecuroides	Chenopodiaceae	many locations	---	---
Allium roseum	Alliaceae	El-Kawm Al-Akhdar	31° 26' 98"	30° 49' 47"
Atriplex canescens	Chenopodiaceae	many locations	---	---
Atriplex leucoclada	Chenopodiaceae	West Burullus pumps Drain No. 11 West Burullus Drain	31° 24' 05" 31° 22' 18" 31° 24' 13"	30° 35' 07" 30° 35' 82" 30° 35' 01"
Ceratophyllum submersum	Ceratophyllaceae	West Burullus pumps	31° 24' 05"	30° 35' 07"
Clerodendrum acerbianum	Verbenaceae	Drain No. 8	31° 21' 56"	30° 48' 03"
Cynomorium coccineum	Cynomoriaceae	El-Kawm Al-Akhdar	31° 26' 98"	30° 49' 47"
Heliotropium curassavicum	Boraginaceae	Quda'ah	31° 31' 59"	30° 48' 84"
Lemna perpusila	Lemnaceae	Birimbal Canal Zaghlol Drain	31° 24' 05" 31° 24' 05"	30° 35' 00" 30° 35' 03"
Ludwigia stolonifera	Onagraceae	many locations	---	---
Lycium schweinfurthii	Solanaceae	El-Kawm Al-Akhdar	31° 26' 98"	30° 49' 47"
Najas minor	Najadaceae	Ash-Shishah	31° 32' 44"	30° 57' 72"
Orobanche cernua	Orobanchaceae	Quda'ah	31° 31' 59"	30° 48' 84"
Orobanche ramosa var. *schweinfurthii*	Orobanchaceae	West Burullus pumps	31° 24' 05"	30° 35' 07"
Scirpus holoschoenus	Cyperaceae	Baltim	31° 33' 37"	31° 04' 86"
Sphaeranthus suaveolens	Asteraceae	Zaghlol Drain	31° 24' 05"	30° 35' 03"
Suaeda pruinosa	Chenopodiaceae	many locations	---	---
Annual rare species				
Parapholis marginatus	Poaceae	Zaghlol Drain	31° 24' 05"	30° 35' 03"
Erodium laciniatum	Geraniaceae	El-Kawm Al-Akhdar	31° 26' 98"	30° 49' 47"
Phalaris paradoxa	Poaceae	Zaghlol Drain	31° 24' 05"	30° 35' 03"
Setaria viridis	Poaceae	Drain No. 8	31° 21' 56"	30° 48' 03"
Bromus catharicus	Poaceae	Quda'ah	31° 31' 59"	30° 48' 84"
Raphanus raphanistrum	Brassicaceae	Many locations	---	---
Amaranthus lividus	Amaranthaceae	Junet Bashkhir	31° 23' 50"	30° 40' 22"
Chenopodium opulifolium	Chenopodiaceae	Many locations	---	---
Chenopodium glaucum	Chenopodiaceae	west of Burullus pumps	31° 24' 05"	30° 35' 07"
Sonchus macrocarpus	Asteraceae	Drain No. 8	31° 21' 56"	30° 48' 03"
Coronopus didymus	Brassicaceae	Drain No. 9	31° 22' 01"	30° 46' 10"
Euphorbia peplis	Euphorbiaceae	El-Kawm Al-Akhdar	31° 26' 98"	30° 49' 47"
Parapholis incurve	Poaceae	El-Kawm Al-Akhdar	31° 26' 98"	30° 49' 47"
Rapistrum rugosum	Brassicaceae	Al-Bughaz	31° 34' 86"	30° 58' 36"
Ranunculus marginatus	Ranunculaceae	El-Kawm Al-Akhdar	31° 26' 98"	30° 49' 47"

Table 4.11. **The position of the perennial species recorded in Burullus Wetland along the geographical, habitat and abundance gradients. Distribution of these species according to the 8 rarity forms are indicated (Rabinowitz 1981). A: Abundant, N: Non-abundant.**

Geographical range	Habitat gradient	Geographical gradient	Abundance gradient	Large				Small			
Habitat specificity				Wide		Narrow		Wide		Narrow	
Abundance		%		A	N	A	N	A	N	A	N
Cressa cretica	50	100	100.0	+							
Cynodon dactylon	80	100	100.0	+							
Cyperus rotundus	50	100	100.0	+							
Eichhornia crassipes	50	50	50.0	+							
Juncus acutus	70	66.7	50.0	+							
Juncus rigidus	50	100	100.0	+							
Phragmites australis	100	91.7	91.7	+							
Polygonum equisetiforme	60	58.3	58.3	+							
Potamogeton pectinatus	50	58.3	58.3	+							
Tamarix nilotica	90	100	100.0	+							
Typha domingensis	50	91.7	91.7	+							
Zygophyllum album var. *album*	70	66.7	66.7	+							
Arthrocnemum macrostachyum	90	58.3	43.8		+						
Aster squamatus	60	75	43.8		+						
Echinochloa stagnina	50	58.3	43.8		+						
Halocnemum strobilaceum	80	50	29.2		+						
Inula crithmoides	70	50	37.5		+						
Paspalidium geminatum	50	58.3	43.8		+						
Sarcocornia fruticosa	90	50	37.5		+						
Suaeda vera	90	58.3	43.8		+						
Aeluropus lagopoides	20	91.7	91.7			+					
Alhagi graecorum	30	91.7	91.7			+					
Centaurea calcitrapa	30	50	50.0			+					
Cistanche phelypaea	10	83.3	62.5			+					
Convolvulus arvensis	30	50	50.0			+					
Convolvulus lanatus	10	50	50.0			+					
Cynanchum acutum	30	50	50.0			+					
Cyperus alopecuroides	30	50	50.0			+					
Cyperus laevigatus	10	100	100.0			+					
Echinops spinosissimus	10	58.3	58.3			+					
Imperata cylindrica	10	91.7	91.7			+					
Launaea nudicaulis	40	100	100.0			+					
Panicum turgidum	10	83.3	83.3			+					
Phyla nodiflora	40	58.3	58.3			+					
Pluchea dioscoridis	20	58.3	58.3			+					
Polypogon viridis	10	91.7	91.7			+					
Potamogeton crispus	20	75	75.0			+					
Saccharum spontaneum	40	75	75.0			+					
Scirpus litoralis	30	58.3	58.3			+					
Scirpus maritimus	30	58.3	58.3			+					
Silybum marianum	10	50	50.0			+					

Table 4.11. Cont. 1.

Geographical range	Habitat gradient	Geographical gradient	Abundance gradient	Large				Small			
Habitat specificity				Wide		Narrow		Wide		Narrow	
Abundance		%		*A*	N	*A*	N	*A*	N	*A*	N
Tamarix aphylla	10	100	100.0			+					
Tamarix tetragyna	20	66.7	50.0			+					
Cornulaca monacantha	10	50	37.5				+				
Juncus subulatus	20	50	37.5				+				
Najas marina v. armata	10	50	37.5				+				
Paspalum distichum	30	50	29.2				+				
Scirpus holoschoenus	10	50	25.0				+				
Wolffia hyalina	20	50	37.5				+				
Persicaria salicifolia	50	41.7	41.7						+		
Suaeda pruinosa	60	25	12.5						+		
Aeluropus littoralis	20	16.7	4.2								+
Agathophora alopecuroides	20	8.3	4.2								+
Allium roseum	10	16.7	8.3								+
Alternanthera sessilis	10	25	18.8								+
Asparagus stipularis	10	41.7	41.7								+
Atriplex canescens	40	16.7	8.3								+
Atriplex halimus	30	25	18.8								+
Atriplex leucoclada	20	41.7	20.8								+
Atriplex nummularia	40	33.3	25.0								+
Atriplex portulacoides	30	16.7	12.5								+
Azolla filiculoides	20	8.3	8.3								+
Centaurea pumilio	20	8.3	6.3								+
Ceratophyllum demersum	40	33.3	33.3								+
Ceratophyllum submersum	10	8.3	2.1								+
Clerodendrum acerbianum	10	8.3	2.1								+
Cynomorium coccineum	20	41.7	20.8								+
Cyperus articulatus	30	41.7	31.3								+
Cyperus capitatus	10	33.3	20.8								+
Elymus farctus	10	16.7	12.5								+
Fagonia arabica	10	33.3	33.3								+
Frankenia revoluta	10	33.3	25.0								+
Heliotropium curassavicum	10	8.3	2.1								+
Ipomoea carnea	20	8.3	8.3								+
Lemna gibba	20	41.7	41.7								+
Lemna perpusilla	40	25	6.3								+
Limoniastrum monpetalum	20	16.7	12.5								+
Limonium pruinosum	20	33.3	25.0								+
Ludwigia stolonifera	30	41.7	20.8								+
Lycium schweinfurthii	10	16.7	4.2								+
Mentha longifolia	20	41.7	31.3								+
Najas minor	10	41.7	20.8								+
Orobanche cernua	10	33.3	16.7								+

Table 4.11. Cont. 2.

Geographical range	Habitat gradient	Geographical gradient %	Abundance gradient	Large				Small			
Habitat specificity				Wide		Narrow		Wide		Narrow	
Abundance				A	N	A	N	A	N	A	N
Orobanche ramosa var. *schweinfurthii*	10	33.3	8.3								+
Pancratium maritimum	10	16.7	12.5								+
Persicaria senegalensis	10	41.7	41.7								+
Plantago major	10	41.7	41.7								+
Salix tetrasperma	10	33.3	25.0								+
Sida alba	10	41.7	31.3								+
Silene succulenta	10	16.7	12.5								+
Sphaeranthus suaveolens	20	33.3	16.7								+
Suaeda maritima	40	33.3	25.0								+
Urginea undulata	10	25	18.8								+
Vigna luteola	10	16.7	12.5								+
Vossia cuspidata	30	8.3	4.2								+
Total species				**12**	**8**	**23**	**6**	**0**	**2**	**0**	**44**
%				**13**	**9**	**24**	**6**	**0**	**2**	**0**	**46**

***Table 4.12.* The position of the annual species recorded in Burullus Wetland along the geographical, habitat and abundance gradients. Distribution of these species according to the 8 rarity forms are indicated (Rabinowitz 1981). A: Abundant, N: Non-abundant.**

Geographical range	Habitat gradient	Geographical gradient %	Abundance gradient	Large				Small			
Habitat specificity				Wide		Narrow		Wide		Narrow	
Abundance				A	N	A	N	A	N	A	N
Chenopodium album	70	50	50.0	+							
Chenopodium ambrosioides	50	50	50.0	+							
Chenopodium murale	50	91.7	91.7	+							
Conyza bonariensis	50	66.7	66.7	+							
Malva parviflora	50	91.7	91.7	+							
Polypogon monspeliensis	80	91.7	91.7	+							
Senecio glaucus subsp. *coronopifolius*	80	75	75.0	+							
Rumex dentatus	50	58.3	37.5		+						
Anagallis arvensis	20	91.7	91.7			+					
Avena fatua	20	83.3	81.3			+					
Beta vulgaris	20	58.3	58.3			+					
Brassica tournefortii	10	66.7	66.7			+					
Cichorium endivia subsp. *pumilum*	30	50	50.0			+					
Cutandia memphitica	30	66.7	66.7			+					
Echinochloa colona	10	100	100.0			+					
Emex spinosa	20	66.7	66.7			+					

Table 4.12. Cont. 1.

Geographical range	Habitat gradient	Geographical gradient %	Abundance gradient	Large				Small			
Habitat specificity				Wide		Narrow		Wide		Narrow	
Abundance				A	N	A	N	A	N	A	N
Eruca sativa	20	75	75.0			+					
Filago desertorum	10	58.3	58.3			+					
Frankenia pulverulenta	10	91.7	91.7			+					
Gnaphalium luteo-album	10	66.7	66.7			+					
Hordeum murinum subsp. *leporinum*	30	83.3	83.3			+					
Ifloga spicata	30	66.7	50.0			+					
Launaea capitata	10	83.3	83.3			+					
Lolium multiflorum	20	58.3	58.3			+					
Lolium perenne	20	75	75.0			+					
Lotus halophilus	20	66.7	66.7			+					
Melilotus indicus	30	83.3	83.3			+					
Orobanche crenata	10	58.3	58.3			+					
Parapholis marginata	20	83.3	50.0			+					
Phalaris minor	20	83.3	62.5			+					
Portulaca oleracea	10	58.3	58.3			+					
Reichardia tingitana	30	91.7	91.7			+					
Schismus barbatus	20	83.3	83.3			+					
Setaria verticillata	10	75	75.0			+					
Silene villosa	10	66.7	66.7			+					
Sisymbrium irio	10	75	75.0			+					
Sonchus oleraceus	40	91.7	91.7			+					
Trifolium alexandrinum	10	58.3	58.3			+					
Trifolium resupinatum	10	58.3	58.3			+					
Trigonella laciniata	20	66.7	66.7			+					
Trigonella stellata	40	66.7	50.0			+					
Urospermum picroides	30	66.7	66.7			+					
Carex divisa	10	58.3	43.8				+				
Cyperus difformis	20	58.3	43.8				+				
Echinochloa crusgalli	30	58.3	43.8				+				
Erodium laciniatum	10	50	25.0				+				
Hordeum marinum	30	58.3	43.8				+				
Juncus bufonius	10	58.3	43.8				+				
Lolium temulentum	20	50	37.5				+				
Medicago intertexa v. *ciliaris*	10	50	37.5				+				
Poa annua	10	50	37.5				+				
Spergula fallax	10	50	37.5				+				
Mesembryanthemum crystallinum	70	33.3	20.8						+		
Mesembryanthemum nodiflorum	80	25	16.9						+		
Chenopodium opulifolium	50	16.7	8.3						+		
Salsola kali	90	41.7	31.3						+		
Spergularia marina	80	41.7	41.7						+		
Sphenopus divaricatus	60	33.3	25.0						+		

Table 4.12 Cont. 2.

Geographical range	Habitat gradient	Geographical gradient	Abundance gradient	Large				Small			
Habitat specificity				Wide		Narrow		Wide		Narrow	
Abundance		%		A	N	A	N	A	N	A	N
Adonis dentata	10	33.3	33.3								+
Amaranthus hybridus	10	25	18.8								+
Amaranthus lividus	10	25	12.5								+
Amaranthus viridis	20	33.3	33.3								+
Ammi visnaga	20	33.3	25.0								+
Anethum graveolens	30	16.7	12.5								+
Astragalus boeticus	10	25	18.8								+
Astragalus peregrinus	10	33.3	25.0								+
Bassia indica	20	41.7	31.3								+
Brassica rapa	10	41.7	31.3								+
Bromus catharicus	10	33.3	16.7								+
Cakile maritima	10	33.3	25.0								+
Carduus pynocephalus	20	33.3	25.0								+
Calendula arvensis	10	66.7	66.7								+
Chenopodium glaucum	20	16.7	4.2								+
Chrysanthemum coronarium	10	41.7	29.2								+
Coriandrum sativum	10	16.7	12.5								+
Coronopus didymus	10	16.7	8.3								+
Coronopus squamatus	10	41.7	31.3								+
Cutandia dichtoma	10	25	20.8								+
Eclipta alba	20	41.7	41.7								+
Euphorbia peplis	10	16.7	8.3								+
Lathyrus marmoratus	10	33.3	25.0								+
Lobularia arabica	10	25	18.8								+
Lotus arabicus	20	25	25.0								+
Medicago polymorpha	30	41.7	41.7								+
Parapholis incurva	10	16.7	8.3								+
Paronychia arabica	10	41.7	27.1								+
Phalaris paradoxa	10	41.7	20.8								+
Ranunculus marginatus	10	8.3	4.2								+
Ranunculus sceleratus	40	33.3	33.3								+
Raphanus raphanistrum	10	25	6.3								+
Rapistrum rugosum	10	16.7	4.2								+
Rorippa palustris	10	33.3	25.0								+
Rumex pictus	10	25	18.8								+
Senecio vulgaris	20	41.7	41.7								+
Setaria viridis	10	41.7	20.8								+
Sinapis arvensis subsp. *allionii*	10	41.7	31.3								+
Sonchus asper	30	41.7	22.9								+
Sonchus macrocarpus	10	16.7	8.3								+
Sporopolus pungens	10	16.7	12.5								+
Total species				**7**	**1**	**35**	**10**	**0**	**6**	**0**	**40**
%				**7**	**1**	**35**	**10**	**0**	**6**	**0**	**41**

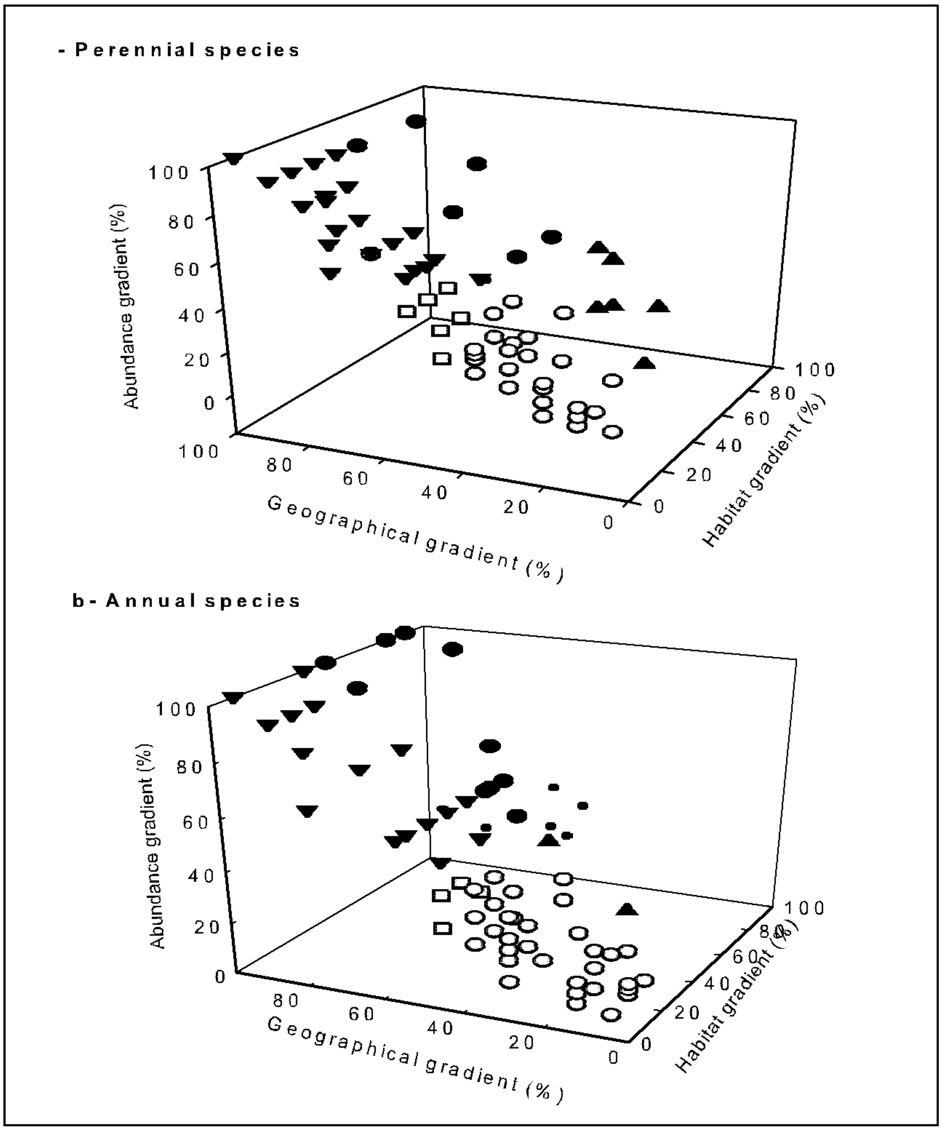


Fig. 4.5. **Ordination of the species recorded in Burullus Wetland along the geographical, habitat and abundance gradients.**

3- ***Bassia indica***. It was introduced in Egypt in 1945 as a promising fodder plant to fill a gap in the ranges of the north western coastal strip of Egypt. After that, it began to invade Nile Delta and other related regions of Nile valley (Drar 1952, Draz 1954, and Thoday *et al.* 1956).

4- ***Aster squamatus.*** It is a common species along the different types of water courses and lakes in Nile Delta. This species was introduced from Latin America, of which the first record in Egypt dates back to the early 1970s, now it is completely naturalized and is considered as one of the most widespread weeds in Egypt (Boulos and El-Hadidi 1994).

5- ***Eichhornia crassipes.*** It was introduced into Egypt in the 1890's as an ornamental plant in public gardens at that time (Täckholm and Drar 1950). Now this plant grows everywhere in the water courses in Nile Valley and Delta. It is the most dangerous aquatic weed in the Egyptian water courses. It infests all water bodies with large cover and causes major problems such as restricting water flow transpiring high amounts of water, hindering navigation and fishing and providing many vectors of human diseases (Ilaco 1985 and Khattab 1988).

6-*Azolla filiculoides*. This fern escaped from experimental fields, which used it for rice fertilization in 1992, and became naturalized in stagnant water of many drainage canals in Nile Delta (Yanni 1992). It formed pure communities especially in the area of control structures and pumping stations (Serag and Khedr 1996, Khedr and El-Demerdash 1997). Now, it is invaded all water courses and Lake Burullus (Al-Sodany 1998). The *Lemna* spp. was replaced by *Azolla* especially in summer (Boulos 1995).

7- ***Vossia cuspidata.*** It is a submerged or floating species that reported as a new record to Egyptian flora by Boulos (1995), but is not known flowering in Egypt (Shehata 1996). Its distribution has been reported throughout Tropical Africa and South East Asia (Skerman and Riveros 1989). It grows in dense and conspicuous populations along Nile and canal banks.

Among the noteworthy species in Lake Burullus are two species that cause severe infestation to the water body of the lake:

1-*Phragmites australis.* An emergent aquatic that is a boon and bane to man. It causes severe infestations to the water body of the lake that hinders the navigation and lead to the fragmentation of the water body. It plays also an important role in increasing the silting process in shallow lakes. On the other hand the plant had a long history of use by man as building material for houses and rafts (e.g. Egypt), as thatching (e.g. England), fodder (e.g. Egypt and other countries). It can be used also as paper pulp and source of bioenergy. Australian and German scientists found this plant to be an effective biological filter for wastewater renovation. The plant also is a source of organic matter and safe refuge for the fish and rests for the birds particularly during winter. Thus what we need is to manage this reed, and not to eradicate it, in order to minimize its negative effects and to maximize its benefits.

2- *Potamogeton pectinatus*. It is the most dominant submerged plant in the lake, tolerant to wide salinity variations but with a tendency or better growth in slightly brackish water (Aleem & Samaan, 1969, Samaan *et al.* 1988). This may explain its wide distribution in the Lake Burullus. It is also a common aquatic plant in inland waters of Egypt, where it inhabits both still and running waters (Täckholm, 1941). It was previously reported by Arber (1920) that this plant usually dies off in autumn, leaving the rhizomes and winter turions to persist in mud till the next spring when new plants start to sprout. In Lake Burullus, a small portion of *Potamogeton pectinatus* was found to persist the winter season.

Ten other species are considered as noteworthy species because they have many economic uses (e.g. multipurpose species). These species are: *Phoenix dactylifera, Tamarix nilotica, Tamarix tetragyna, Phragmites australis, Alhagi graecorum, Atriplex halimus, Panicum turgidum, Ricinus communis, Tamarix aphylla, Typha domingensis*. They are discussed in details with the other economic important species under a separate topic (4.3).

4.1.5. Comparison with the Northern Lakes

Hussein (2005) has carried out a comparative floristic and phytosociological study on the five main lakes extend along the Mediterranean coastal region of Egypt: Mariut (Western Coast), Edku, Burullus and Manzala (Deltaic Coast) and Bardawil (Sinai Coast). He recorded a total of 404 species, representing about 20% of the total flora of Egypt, and belonging to 250 genera and 69 families. Lake Burullus contributed the highest number of species (224 species: 55% of the total recorded species), followed by Lakes Mariut (199 species: 49.3%), Manzala (145 species: 35.6%), Bardawil (136 species: 33.6%) and Edku (120 species: 29.7%). 69 families were recorded in the study area, lake Burullus contributed 68.1% of the recorded families. *Cynomoraceae* and *Salicaceae* were restricted to Lake Burullus (Fig. 4.6).

A total of 191 species were unique to only one of the five lakes, of which 52 species (about 27%) were restricted to Lake Burullus (22 annuals and 30 perennials) (Fig. 4.7). Seven species (1.7% of the total recorded species) were endemic taxa, three of which were recorded in lake Burullus: *Zygophyllum aegyptium, Sinapis allionii* and *Sonchus macrocarpus*.

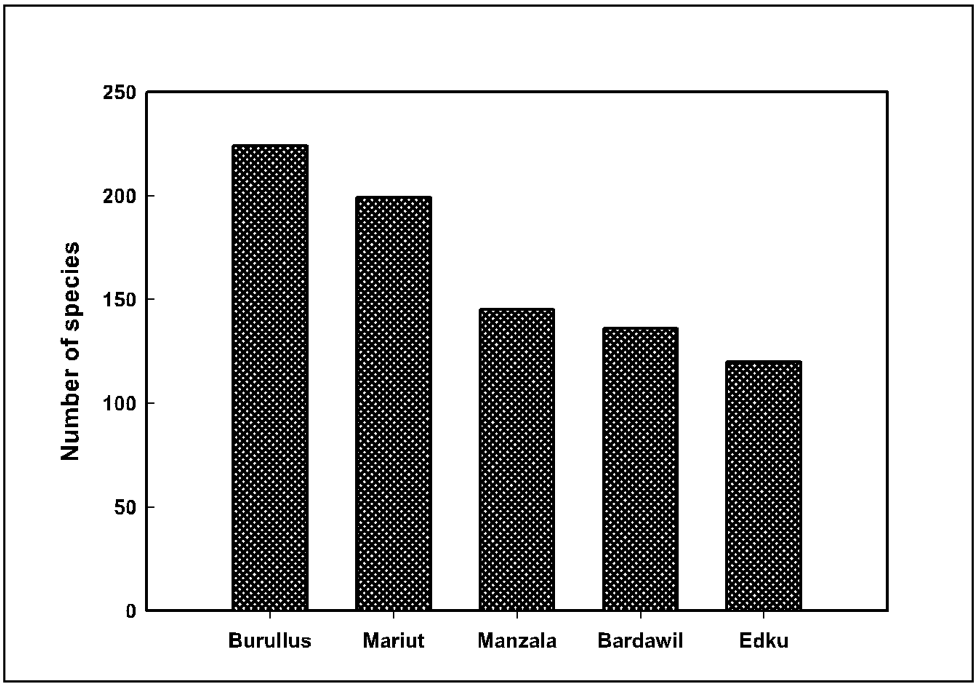


Fig. 4.6. Number of species recorded in each of the five northern lakes (after Hussein 2005).

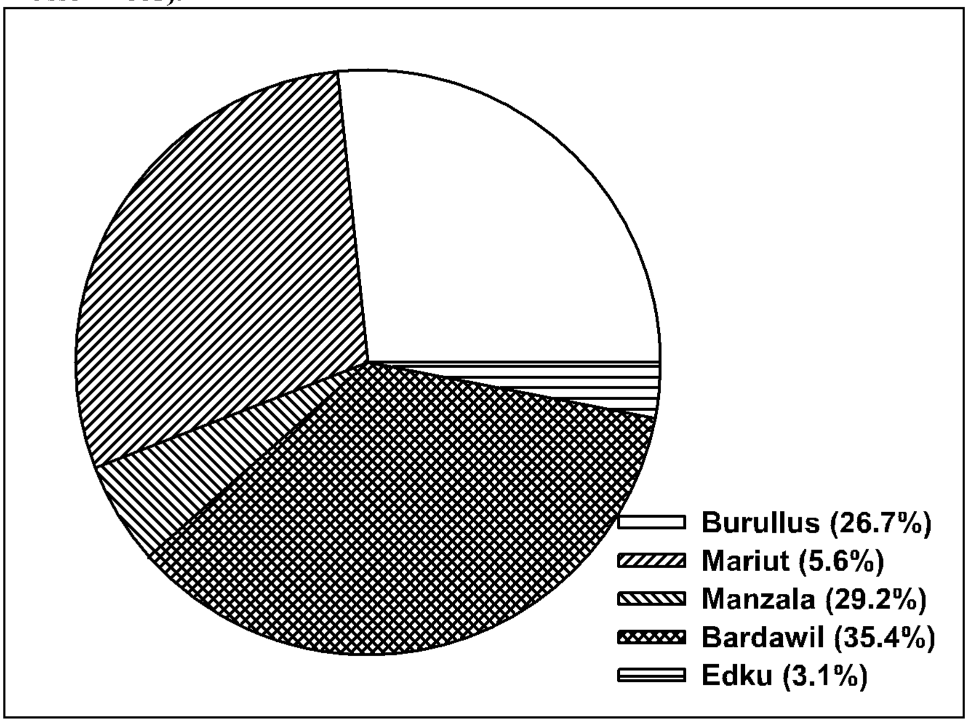


Fig. 4.7. Number of species unique to each of the five northern lakes (after Hussein 2005).

The application of Shannon diversity index, that evaluates the relative evenness of species dominance, indicated that Lake Burullus, which has the second largest area after Lake Manzala, had the highest relative evenness of species (5.4), followed by Mariut, Manzala, Bardawil and Edku with values of 5.3, 5.0, 4.9 and 4.8, respectively (Hussein 2005).

4.2. VEGETATION

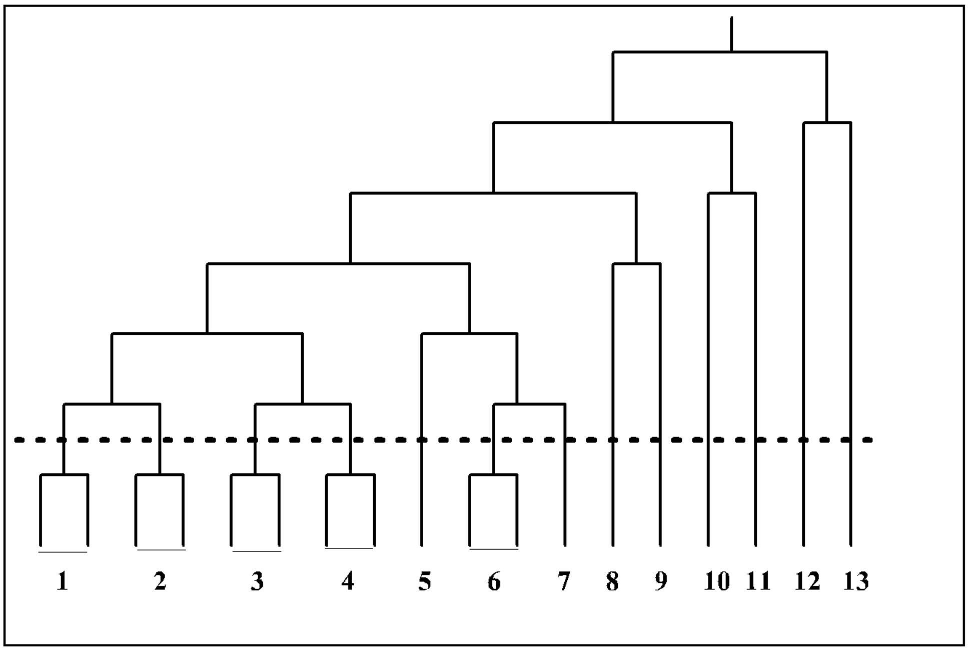
The application of TWINSPAN classification (Hill 1979 a, Gauch and Wittaker 1981) on the cover estimates (following Canfield 1941) of 197 species recorded in 227 stands in Burullus Wetland by Shaltout and Al-Sodany (2000), led to the recognition of 13 vegetation groups at the 6^{th} level of classification (Fig. 4.8). The application of DECORANA ordination (Hill 1979 b, Hill and Gauch 1980) on the same set of data indicates a reasonable segregation between the stands of some of these groups (Fig. 4.9). The vegetation groups are named after the first and second dominant species (i.e. the species that have the highest presence percentage and/or the highest relative cover). The following is a brief description of these vegetation groups (Tables 4.13 and 4.14):

1- *Arthrocnemum macrostachyum-Juncus acutus* group. It comprises 9 stands (4% of the total stands) and 37 species. 78% of its stands are in the islets. The dominant species are *Arthrocnemum macrostachyum* (P = 100%, C = 34%) and *Juncus acutus* (P = 44%, C = 31%). Other frequent species are: *Atriplex portulacoides*, *Inula crithmoides*, and *Phragmites australis*.

2- *Phragmites australis-Suaeda pruinosa* group. It comprises 10 stands (4.4% of the total stands) and 55 species. 40% of its stands occur along the terraces of drains. The dominant species are *Phragmites australis* (P = 60%, C = 59%) and *Suaeda pruinosa* (P = 50%, C = 31%). Other frequent species are: *Arthrocnemum macrostachyum* and *Malva parviflora*.

3- Phragmites australis-Arthrocnemum macrostachyum group includes 150 stands (66.1% of the total stands) and 170 species, thus it is considered the most widespread plant community in Lake Burullus. Its stands are scattered in many habitats in this wetland. The dominant species are *Arthrocnemum macrostachyum* (P = 48%, C = 17%) and *Phragmites australis* (P = 44%, C = 22%).

4- *Suaeda vera - Inula crithmoides* group comprises 8 stands (3.5% of the total stands) and 53 species. 50% of its stands occur along the water edges of the drains and islets (25% for each habitat). The dominant species are *Suaeda vera* (P = 63%, C = 28%) and *Inula crithmoides* (P = 50%, C = 27%).



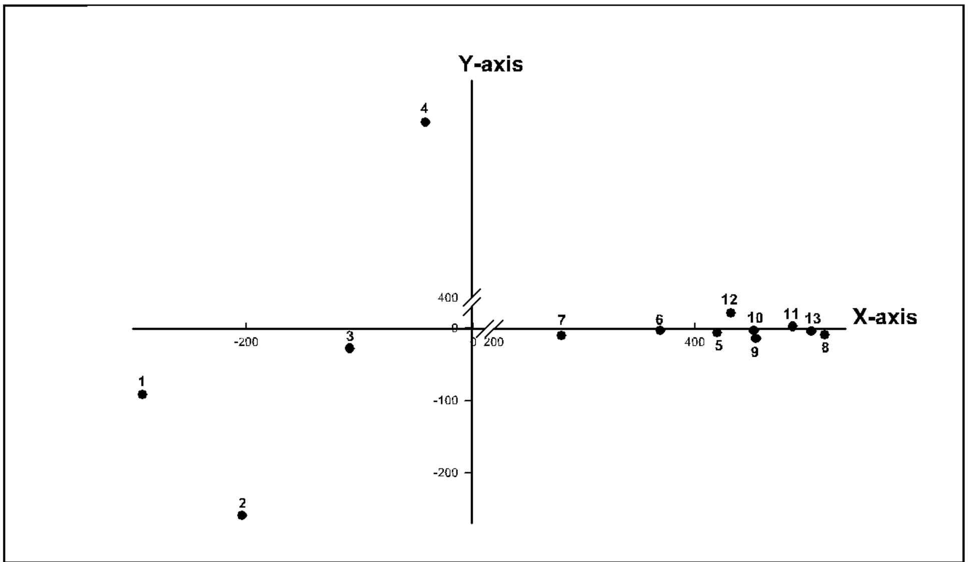


Fig. 4.8. The relationship between the 13 vegetation groups which generated after application of TWINSPAN classification technique (A) and their cluster centroides on the first and second axes of DECORANA (B). The names of these groups are: 1: *Arthrocnemum macrostachyum-Juncus acutus*, 2: *Phragmites australis-Suaeda pruinosa*, 3: *Phragmites australis-Arthrocnemum macrostachyum*, 4: *Suaeda pruinosa-Inula crithmoides*, 5: *Juncus acutus*, 6: *Sarcocornia fruticosa*, 7: *Potamogeton pectinatus*, 8: *Halocnemum strobilaceum*, 9: *Salsola kali*, 10: *Phragmites australis*, 11: *Phragmites australis-Potamogeton pectinatus*, 12: *Typha domingensis-Ceratophyllum demersum*, and 13: *Phragmites australis-Potamogeton pectinatus.*

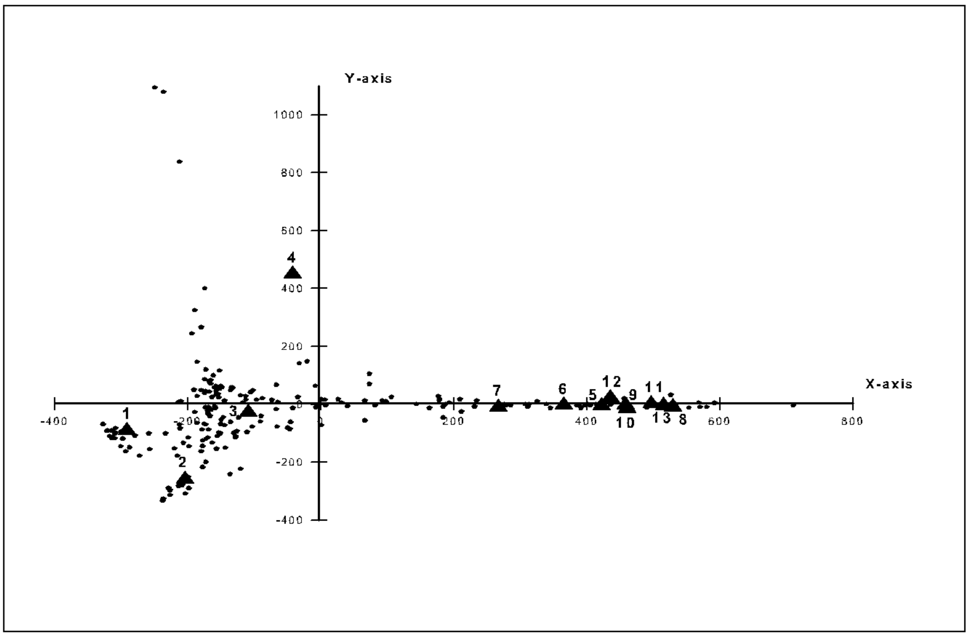


***Fig. 4.9.* Ordination of 227 stands according to DECORANA technique. The solid triangles represent cluster centroides of 13 vegetation groups derived after the application of TWINSPAN.**

5- *Juncus acutus* group has only 3 stands (1.3% of the total stands) and 27 species. Two of its stands present along the lake shores. The dominant species is *Juncus acutus* (P = 100%, C = 17%). Other frequent species are: *Phragmites australis, Scirpus litoralis, Polypogon monspeliensis, Sarcocornia fruticosa, Arthrocnemum macrostachyum, Senecio glaucus* subsp. *coronopifolius, Sphenopus divaricatus, Salsola kali, Rumex dentatus, Cynodon dactylon, Juncus subulatus* and *Polygonum equisetiforme.*

Table 4.13. **Characteristics of the 13 vegetation groups derived after the application of TWINSPAN. N: number of stands, G/P: the percentage of the stands representing each vegetation group in relation to the total sampled stands, The types of habitats are: SM: salt marshes, SS: sand formations, LG: lake cuts, TD: terraces, SD: slopes, ED: water edges and OD: open water zones of the drains, LS: lake shores, LO: open water of the lake and IS: lake islets. P: presence of species (%), C: relative cover of species (%).**

VG	N	Total spp.	G/P (%)	Types of habitat										First dominant	P (%)	C (%)	Second dominant	P (%)	C (%)
				SM	SS	LG	TD	SD	ED	OD	LS	LO	IS						
1	9	37	4.0	11		11							78	*Arthrocnemum macrostachyum*	100	41	*Juncus acutus*	44	31
2	10	55	4.4	20	10		40	10				20		*Phragnites australis*	60	59	*Suaeda pruinosa*	50	12
3	150	170	66.1	16	8	6	7	13	11	7	4	5	21	*Phragnites australis*	48	17	*Arthrocnemum macrostachyum*	44	22
4	8	53	3.5				13	13	25	13		13	25	*Suaeda vera*	63	28	*Inula crithmoides*	50	27
5	3	27	1.3						33		67			*Juncus acutus*	100	17	*Phragmites australis*	100	6
6	11	50	4.9				18		18		55		9	*Sarcocornia fruticosa*	73	53	*Arthrocnemum macrostachyum*	64	5
7	10	11	4.4							10		90		*Potamogeton pectinatus*	100	87	*Eichhornia crassipes*	90	10
8	3	16	1.3				33			33			33	*Halocnemum strobilaceum*	67	21	*Polypogon monspeliensis*	67	9
9	2	10	0.9				50	50						*Salsola kali*	100	31	*Senecio glaucus subsp. coronopifolius*	100	8
10	5	39	2.2				20				80			*Phragnites australis*	80	18	*Typha domingensis*	80	6
11	6	18	2.6				17			17		67		*Phragnites australis*	100	51	*Potamogeton pectinatus*	50	23
12	3	16	1.3									33	67	*Typha domingensis*	67	51	*Ceratophyllum demersum*	67	22
13	7	36	3.1				29	14				57		*Phragnites australis*	71	15	*Potamogeton pectinatus*	43	9

Table 4.14. **Presence percentages of the recorded species in the 13 vegetation groups derived after the application of TWINSPAN.**

Species	Vegetation group													Tot
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	
Agathophora alopecuroides			1			18								**2**
Alhagi graecorum	11	10	6											**3**
Alternanthera sessilis	11													**1**
Amaranthus hybridus			1											**1**
Amaranthus lividus	11													**1**
Amaranthus viridis			2							20				**2**
Anagallis arvensis			1											**1**
Anethum graveolens	11		1											**2**
Astragalus peregrinus			1											**1**
Atriplex canescens	11	20	5	13	33									**5**
Atriplex halimus			2										14	**1**
Atriplex portulacoides	44		8	25		9				60		67	14	**7**
Bromus catharicus			1											**1**
Carex divisa			1											**1**
Chenopodium glaucum			1											**1**
Chrysanthemum coronarium										20				**1**
Cistanche phelypaea			1											**1**
Coriandrum sativum			1											**1**
Cynomorium coccineum			1	25										**2**
Cyperus capitatus			1											**1**
Cyperus difformis		10	1											**2**
Cyperus laevigatus			1											**1**
Cyperus rotundus		10	1		33									**3**
Echinochloa colona												33		**1**
Elymus farctus			1							20				**2**
Eruca sativa			1											**1**
Fagonia arabica			1											**1**
Filago desertorum			1											**1**
Frankenia revoluta	11		1											**2**
Imperata cylindrica			1											**1**
Inula crithmoides	44	10	21	50	33	9			50	60		67		**9**
Juncus bufonius		10	1										14	**3**
Limoniastrum monopetalum			2											**1**
Limonium pruinosum	11		3			9								**3**
Lotus arabicus		20	1	13										**3**
Medicago intertexa v. *ciliaris*			1											**1**
Mentha longifolia		10	1											**2**
Orobanche crenata			2											**1**
Orobanche ramosa var. *schweinfurthii*					33									**1**
Phalaris paradoxa			1											**1**
Phoenix dactylifera												33		**1**
Plantago major				13										**1**
Polypogon viridis		10	1											**2**
Portulaca oleracea			1											**1**
Raphanus raphanistrum			2											**1**
Rapistrum rugosum	11		1											**2**

Table 4.14. Cont. 1.

Species	Vegetation group													Tot
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Ricinus communis	11		1											**2**
Salix tetrasperma				13										**1**
Scirpus holoschoenus			1											**1**
Scirpus litoralis	11		3		67	18				60			14	**6**
Silene succulenta			1											**1**
Sisymbrium irio			1											**1**
Sonchus macrocarpus			1											**1**
Spergula fallax			1											**1**
Sphaeranthus suaveolens			1											**1**
Suaeda pruinosa	11	40	19	13	33									**5**
Suaeda vera	33	10	18	63		27			50					**6**
Tamarix aphylla			3											**1**
Tamarix tetragyna										20				**1**
Trifolium alexandrinum		10												**1**
Trifolium resupinatum		10		13										**2**
Trigonella laciniata		10	3	13	33									**4**
Trigonella stellata		20	3											**2**
Urospermum picroides			1	13										**2**
Aeluropus lagopoides	11		5	25										**3**
Hordeum marinum		20	2											**2**
Hordeum murinum subsp. *leporinum*		30	5	13									14	**4**
Polypogon monspeliensis		30	11	25	100	9		67		20			14	**8**
Sarcocornia fruticosa	33		27	25	67	73		33	50	60	17	33	14	**11**
Arthrocnemum macrostachyum	100	40	48	38	100	64		67		80		67	14	**10**
Mesembryanthemum nodiflorum	22	20	13	13	33	27			50		17			**8**
Adonis dentata			1											**1**
Allium roseum			1											**1**
Asparagus stipularis			4											**1**
Astragalus boeticus	11													**1**
Avena fatua			1											**1**
Bassia indica						9								**1**
Beta vulgaris		20	6	13		9								**4**
Brassica rapa			1											**1**
Brassica tournefortii	11													**1**
Calendula arvensis			1											**1**
Carduus pynocephalus			1	13										**2**
Chenopodium murale		30	7	13		18							14	**5**
Cichorium endivia subsp. *pumilum*			3	13										**2**
Convolvulus arvensis			1	13		9								**3**
Coronopus squamatus						9								**1**
Cutandia dichtoma			1											**1**
Cutandia memphitica			4											**1**
Echinops spinosissimus			1											**1**
Emex spinosa			2											**1**
Erodium laciniatum	11													**1**
Euphorbia peplis			1											**1**
Gnaphalium luteo-album			1											**1**

Table 4.14. Cont. 2.

Species	Vegetation group													Tot
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Hordeum vulgare		10	2											**2**
Lathyrus marmoratus			1											**1**
Launaea capitata			3											**1**
Lobularia arabica			3											**1**
Lolium multiflorum			1							20				**2**
Lolium perenne		10	2	13										**3**
Lolium temulentum			2	13										**2**
Lycium schweinfurthii			5											**1**
Medicago polymorpha	11	10	5	13										**4**
Melilotus indicus		10	1	25		9				20				**5**
Pancratium maritimum			2											**1**
Parapholis incurva			1											**1**
Parapholis marginata			1											**1**
Paronychia arabica			1											**1**
Phalaris minor				13		9				20				**3**
Ranunculus marginatus			1											**1**
Senecio vulgaris		10	2											**2**
Silene villosa			1											**1**
Silybum marianum			1											**1**
Sinapis arvensis subsp. *allionii*			3											**1**
Sonchus oleraceus		30	5	13										**3**
Sporopolus pungens			2											**1**
Urginea undulata			1											**1**
Atriplex nummularia		10	3	13		27							14	**5**
Centautea calcitrapa			3	13									14	**3**
Malva parviflora	11	40	7	13		18				40				**6**
Scirpus maritimus	11		4		33	9						67		**5**
Mesembryanthemum crystallinum	11		13			9			50	20			14	**6**
Atriplex leucoclada								33					14	**2**
Cakile maritima			1											**1**
Cressa cretica	11		5			9			50		17		14	**6**
Ifloga spicata			3											**1**
Reichardia tingitana			4											**1**
Schismus barbatus			4											**1**
Senecio glaucus subsp. *coronopifolius*	22	30	23	13	67	9		33	100	20	17		14	**11**
Sphenopus divaricatus	11		4		67			33		60				**5**
Zygophyllum album var. *album*	11	10	13	25				33		20	17			**7**
Centaurea pumilio			4								17			**2**
Convolvulus lanatus			1											**1**
Cornulaca monacantha			1											**1**
Frankenia pulverulenta			1											**1**
Halocnemum strobilaceum	33	30	27		33	9		67		40				**7**
Heliotropium curassavicum			1											**1**
Launaea nudicaulis			3											**1**
Lotus halophilus			2											**1**
Panicum repens							10							**1**
Panicum turgidum			1											**1**

Table 4.14. Cont. 3.

Species	Vegetation group													Tot
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Rumex pictus			1											**1**
Salsola kali	11	20	34	13	67	9		33	100	40	17		14	**11**
Suaeda maritima		10	1			18		33	50	20	17		29	**8**
Chenopodium album			4	13		18								**3**
Conyza bonariensis		30	3											**2**
Cyperus articulatus			1							20				**2**
Echinochloa crusgalli			1			9								**2**
Persicaria salicifolia		10	1	13						20			14	**5**
Chenopodium opulifolium			1							20				**2**
Cynanchum acutum			1	13										**2**
Ranunculus sceleratus			5					33				33	14	**4**
Rumex dentatus		30	13	13	67	18				60			14	**7**
Spergularia marina	11	30	23	13	33	64		67	50		17	33	29	**11**
Chenopodium ambrosioides		20	6		33	55		33						**5**
Juncus acutus	44	20	15	25	100	36						67	14	**7**
Lemna perpusilla			1			9								**2**
Ludwigia stolonifera			1			9	10			40	17			**5**
Paspalum distichum			1			9				20			14	**4**
Saccharum spontaneum		10	1											**2**
Ceratophyllum submersum		10												**1**
Clerodendrum acerbianum			1											**1**
Setaria verticillata			1											**1**
Setaria viridis			1											**1**
Sida alba			1											**1**
Ammi visnaga			1										14	**2**
Eclipta alba			1			9				20				**3**
Ipomoea carnea			5											**1**
Paspalidium geminatum		10	1			9				20				**4**
Persicaria senegalensis										20				**1**
Pluchea diosciridis			1										14	**2**
Poa annua						9								**1**
Rorippa palustris			1											**1**
Sonchus asper			1			9				20				**3**
Vigna luteola										20				**1**
Vossia cuspidata			1			9				20				**3**
Tamarix nilotica		30	13	13	33	36		33		40		67	14	**9**
Juncus rigidus	33	20	16	25										**4**
Aster squamatus		20	7	13		9				20			14	**6**
Cynodon dactylon			13	13	67									**3**
Juncus subulatus			3		67	27								**3**
Polygonum equisetiforme		10	14	25	67	36		33					14	**7**
Phragmites australis	44	60	44	50	100	55	70	33		80	100	67	71	**12**
Cyperus alopecuroides		10	1	13										**3**
Typha domingensis	11	20	8	38	33	18	40			80		67	29	**9**
Wolffia hyalina				13						20			14	**2**
Phyla nodiflora		10	4	13	33	9								**5**
Najas marina v. armata			1				10				33	33	29	**5**
Najas minor			1											**1**
Azolla filiculoides		20	3	13										**3**

Table 4.14. Cont. 3.

Species	Vegetation group													Tot
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Lemna gibba			3				10							**2**
Potamogeton crispus			3				10							**2**
Ceratophyllum demersum		10	5				40				50	67	43	**6**
Potamogeton pectinatus		20	8	13		9	100				67	33	43	**8**
Echinochloa stagnina			4			9	20			20	17		14	**6**
Eichhornia crassipes			7			9	90				67		43	**5**
Total species	**37**	**55**	**170**	**53**	**27**	**50**	**11**	**16**	**10**	**39**	**18**	**16**	**36**	**197**

6- *Sarcocornia fruticosa* group comprises 11 stands (4.9% of the total stands) and 50 species. 55% of its stands present along the lake shores. The dominant species is *Sarcocornia fruticosa* (P = 73%, C = 53%). Other frequent species are: *Arthrocnemum macrostachyum, Spergularia marina, Chenopodium ambrosioides* and *Phragmites australis*.

7- *Potamogeton pectinatus* group includes 10 stands (4.4% of the total stands) and 11 species. It mainly presents along the open water of the lake (90% of its stands). The dominant species is *Potamogeton pectinatus* (P = 100%, C = 87%). Other frequent species are: *Eichhornia crassipes, Phragmites australis, Typha domingensis* and *Ceratophyllum demersum*. Although this group is represented by 10 stands only (due to the relative homogeneity of its floristic composition) but it occupies vast areas of the open water of the lake.

8- *Halocnemum strobilaceum* group has only 3 stands (1.3% of the total stands) and 16 species. The stands of this group occur along the terrace and open water zones of the drains and islets. The dominant species is *Halocnemum strobilaceum* (P = 67%, C = 21%). Other frequent species are: *Polypogon monspeliensis, Arthrocnemum macrostachyum* and *Spergularia marina*.

9- *Salsola kali* group comprises only 2 stands (0.9% of the total stands) and 10 species. It inhabits the terraces and slopes of the drains. The dominant species is *Salsola kali* (P = 100%, C = 31%). Other frequent species are: *Senecio glaucus* subsp. *coronopifolius, Inula crithmoides, Suaeda vera, Sarcocornia fruticosa, Mesembryanthemum nodiflorum, Cressa cretica* and *Spergularia marina*.

10- *Phragmites australis* group comprises 5 stands (2.2% of the total stands) and 39 species. It mainly occurs along the lake shores (80% of its stands). The dominant species is *Phragmites australis* (P = 80%, C = 18%). Other frequent species are: *Typha domingensis, Atriplex portulacoides, Inula crithmoides, Scirpus litoralis, Sarcocornia fruticosa, Arthrocnemum macrostachyum, Sphenopus divaricatus* and *Rumex dentatus*.

11- *Phragmites australis - Potamogeton pectinatus* group has 6 stands (2.6% of the total stands) and 18 species. It characterized the vegetation of the open water of the lake. The dominant species are *Phragmites australis* (P = 80%, C = 51%) and *Potamogeton pectinatus* (P = 67%, C = 23%). Other frequent species are: *Ceratophyllum demersum* and *Eichhornia crassipes*.

12- *Typha domingensis - Ceratophyllum demersum* group comprises only 3 stands (1.3% of the total stands) and 16 species. Two of its stands occur in the islets (67% of its stands). The dominant species are *Typha domingensis* (P = 67%, C = 51%) and *Ceratophyllum demersum* (P = 67%, C = 22%). Other frequent species are: *Atriplex portulacoides, Inula crithmoides, Arthrocnemum macrostachyum, Scirpus maritimus, Juncus acutus, Tamarix nilotica* and *Phragmites australis*.

13- *Phragmites australis-Potamogeton pectinatus* group includes 7 stands (3.1% of the total stands) and 36 species. 57% of its stands occur in the open water of the lake. The dominant species are *Phragmites australis* (P = 71%, C = 15) and *Potamogeton pectinatus* (P = 43%, C = 9%). Other frequent species are: *Ceratophyllum demersum* and *Eichhornia crassipes*. This vegetation group is closely related to group 11, but it is characterized by higher species richness (36 species), as compared with group 11 (18 species).

4.3. ECONOMIC IMPORTANCE OF THE RECORDED SPECIES

The potential and actual economic uses of the recorded species in Burullus Wetland were assessed based on; field observations, information collected from local inhabitants, and literature review (Traux *et al.* 1972, Täckholm 1974, FAO 1979, Haslam 1978, El-Kady 1980, Zohary 1966 & 1987, Feinbrun-Dothan 1978 & 1986, Danin 1983, Boulos 1983 & 1989, Sculthorpe 1985, Mossa *et al.* 1987, Mandaville 1990, Ayyad 1992, Belal and Springuel 1996, Shaltout 1997, Zahran & Willis 2003). The economic uses are classified into 6 major categories: grazing, fuel, medicinal use, human food, timber and other uses (e.g. making mats, baskets, ropes, chairs, ornamental uses, beach bed, sand binder, soap manufacture and oil and dye extraction). As all the plants are ecologically important (e.g. keeping stability and biodiversity of the ecosystems, sharing in soil stabilization and symbiosis, etc.), this criterion was not taken into consideration in the evaluation of the economic importance of the plants.

The economic uses of the recorded species could be arranged descendingly as follows grazing → medicinal → other uses → human food → fuel → timber

(Fig. 4.8). One hundred and forty-one species (72 perennials and 69 annuals) of the recorded species in this area (71.4% of the total species) have at least one aspect of the potential or actual economic uses. Ten species have ≥ 4 (out of 6) economic aspects: *Phoenix dactylifera, Tamarix nilotica, Tamarix tetragyna, Phragmites australis, Alhagi graecorum, Atriplex halimus, Panicum turgidum, Ricinus communis, Tamarix aphylla* and *Typha domingensis* (Tables 4.15, 4.16).

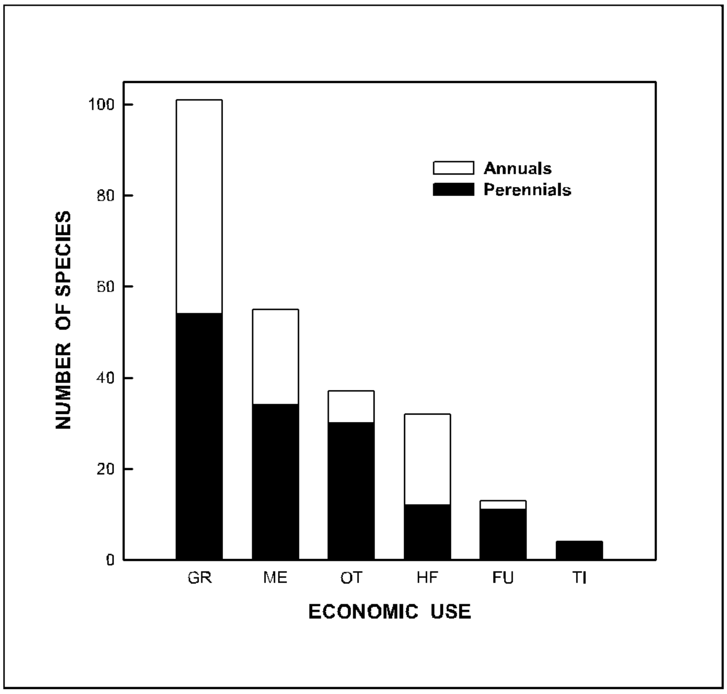


Fig. 4.10. **Descending arrangement of the economic uses of the recorded species in Burullus Wetland. GR: grazing, ME: medicinal, OT: other uses, HF: human food, FU: fuel and TI: timber use.**

4.3.1. Grazing

The domestic and wild animals can graze and browse 101 species (54 perennials and 47 annuals). They represent 71.6% of the total economic species. Among the high palatable species are some grasses (e.g. *Aeluropus lagopoides, Panicum turgidum, Phragmites australis, Echinochloa stagnina, Cynodon dactylon, Paspalum distichum, Paspalidium geminatum* and *Echinochloa crusgalli*), legumes (e.g. *Alhagi graecorum, Melilotus indicus, Medicago polymorpha, Trifolium alexandrinum* and *Trigonella stellata*) and sedges (e.g. *Cyperus rotundus, Cyperus laevigatus, Scirpus litoralis and Scirpus maritimus*).

Table 4.15. **Economic importance of the perennial species recorded in Burullus Wetland. GR: grazing, FU: fuel, ME: medicinal use, HF: human food, and TI: timber. EI: economic index (out of 6).**

Species	GR	FU	ME	HF	TI	Other	EI
Phoenix dactylifera	+	+	+	+	+	+	**6**
Tamarix nilotica	+	+	+		+	+	**5**
Tamarix tetragyna	+	+	+		+	+	**5**
Phragmites australis	+	+	+	+		+	**5**
Alhagi graecorum	+	+	+	+			**4**
Atriplex halimus	+		+	+		+	**4**
Panicum turgidum	+		+	+		+	**4**
Ricinus communis		+	+	+		+	**4**
Tamarix aphylla		+	+		+	+	**4**
Typha domingensis	+		+	+		+	**4**
Arthrocnemum macrostachyum	+	+				+	**3**
Halocnemum strobilaceum	+	+				+	**3**
Sarcocornia fruticosa	+	+				+	**3**
Cynodon dactylon	+		+			+	**3**
Cynomorium coccineum	+		+	+			**3**
Imperata cylindrica	+		+			+	**3**
Ipomoea carnea	+		+			+	**3**
Juncus acutus	+		+			+	**3**
Juncus rigidus	+		+			+	**3**
Asparagus stipularis	+		+				**2**
Cyperus rotundus	+		+				**2**
Launaea nudicaulis	+		+				**2**
Saccharum spontaneum	+		+				**2**
Aeluropus lagopoides	+			+			**2**
Polygonum equisetiforme	+					+	**2**
Suaeda pruinosa	+					+	**2**
Suaeda vera	+					+	**2**
Centautea calcitrapa			+	+			**2**
Mentha longifolia			+	+			**2**
Urginea undulata			+			+	**2**
Vossia cuspidata	+					+	**2**
Cyperus articulatus			+			+	**2**
Lycium schweinfurthii		+				+	**2**
Aeluropus massauensis	+						**1**
Agathophora alopecuroides	+						**1**
Aster squamatus	+						**1**
Atriplex nummularia	+						**1**
Atriplex portulacoides	+						**1**
Convolvulus lanatus	+						**1**

Table 4.15. Cont. 1.

Species	GR	FU	ME	HF	TI	Other	EI
Cyperus laevigatus	+						**1**
Echinochloa stagnina	+						**1**
Echinops spinosissimus	+						**1**
Elymus farctus	+						**1**
Juncus subulatus	+						**1**
Limonium pruinosum	+						**1**
Paspalidium geminatum	+						**1**
Paspalum distichum	+						**1**
Phyla nodiflora	+						**1**
Polypogon viridis	+						**1**
Scirpus holoschoenus	+						**1**
Scirpus litoralis	+						**1**
Scirpus maritimus	+						**1**
Cistanche phelypaea			+				**1**
Convolvulus arvensis			+				**1**
Cornulaca monacantha			+				**1**
Cressa cretica			+				**1**
Pancratium maritimum			+				**1**
Plantago major			+				**1**
Pluchea dioscoridis			+				**1**
Silybum marianum			+				**1**
Allium roseum				+			**1**
Clerodendrum acerbianum						+	**1**
Cyperus alopecuroides						+	**1**
Hydrophytes							
Azolla filiculoides	+		+			+	**3**
Ceratophyllum demersum	+		+				**2**
Eichhornia crassipes	+					+	**2**
Lemna gibba	+					+	**2**
Lemna perpusilla	+					+	**2**
Ceratophyllum submersum	+						**1**
Potamogeton crispus	+						**1**
Potamogeton pectinatus	+						**1**
Wolffia hyalina	+						**1**
Total perennials	**54**	**11**	**34**	**12**	**4**	**30**	**72**

Table 4.16. **Economic importance of the annual species recorded in Burullus Wetland. GR: grazing, FU: fuel, ME: medicinal use, HF: human food, and TI: timber. EI: economic index (out of 6).**

Species	GR	FU	ME	HF	TI	Other	EI
Emex spinosa	+		+	+			**3**
Malva parviflora	+		+	+			**3**
Portulaca oleracea	+		+	+			**3**
Ifloga spicata	+		+			+	**3**
Salsola kali			+	+		+	**3**
Lolium perenne	+	+					**2**
Lolium temulentum	+	+					**2**
Hordeum vulgare	+		+				**2**
Melilotus indicus	+		+				**2**
Rumex dentatus	+			+			**2**
Rumex pictus	+			+			**2**
Sonchus asper	+			+			**2**
Sonchus macrocarpus	+			+			**2**
Sonchus oleraceus	+			+			**2**
Anethum graveolens			+	+			**2**
Chenopodium album			+	+			**2**
Cichorium endivia subsp. *pumilum*			+	+			**2**
Coriandrum sativum			+	+			**2**
Eruca sativa			+	+			**2**
Raphanus raphanistrum			+	+			**2**
Ammi visnaga			+			+	**2**
Chrysanthemum coronarium			+			+	**2**
Bassia indica	+						**1**
Bromus catharicus	+						**1**
Cutandia dichtoma	+						**1**
Cutandia memphitica	+						**1**
Cyperus difformis	+						**1**
Echinochloa colona	+						**1**
Echinochloa crusgalli	+						**1**
Filago desertorum	+						**1**
Hordeum marinum	+						**1**
Hordeum murinum subsp. *leporinum*	+						**1**
Juncus bufonius	+						**1**
Lolium multiflorum	+						**1**
Medicago intertexa v. *ciliaris*	+						**1**
Medicago polymorpha	+						**1**
Paranychia arabica	+						**1**
Parapholis incurva	+						**1**
Parapholis marginata	+						**1**
Phalaris minor	+						**1**

Table 4.16. Cont. 1.

Species	GR	FU	ME	HF	TI	Other	EI
Phalaris paradoxa	+						1
Poa annua	+						1
Polypogon monspeliensis	+						1
Reichardia tingitana	+						1
Schismus barbatus	+						1
Setaria verticillata	+						1
Setaria viridis	+						1
Sisymbrium irio	+						1
Spergula fallax	+						1
Spergularia marina	+						1
Sporopolus pungens	+						1
Trifolium alexandrinum	+						1
Trifolium resupinatum	+						1
Trigonella laciniata	+						1
Trigonella stellata	+						1
Urospermum picroides	+						1
Chenopodium ambrosioides			+				1
Chenopodium opulifolium				+			1
Conyza bonariensis			+				1
Eclipta alba			+				1
Erodium laciniatum			+				1
Euphorbia peplis			+				1
Ranunculus sceleratus			+				1
Beta vulgaris				+			1
Brassica rapa				+			1
Chenopodium murale				+			1
Senecio glaucus subsp. *Coronopifolius*				+			1
Brassica tournefortii						+	1
Sphenopus divaricatus						+	1
Total annuals	**47**	**2**	**21**	**20**	**0**	**6**	**69**
Total species	**101**	**13**	**55**	**32**	**4**	**37**	**141**

There are some examples of selective use of different plant organs at different seasons. Small branches of *Tamarix nilotica* are apparently good for camels and goats, while sheep prefer its flowers only. The same species seems to be more palatable in winter than in summer, as the high salt content in its foliage in summer makes animal thirsty. Species of *Azolla* and *Lemna* together with *Eichhornia crassipes* and some hydrophytes are commonly collected in vast quantities and used as manure or fodder for cattle and pigs in Tropical Africa,

India and south-east Asia. Birds and fishes often feed on the fruits and shoots of some species such as *Ceratophyllum*, *Lemna* and *Potamogeton* (Sculthorpe 1985).

4.3.2. Fuel

Thirteen species are subjected to cutting for fuel (9.2% of the total economic species). Local inhabitants usually use the dry parts and cut green plants when they cannot find dry ones. Most of the shrubby species are cut and harvested for fuel (e.g. *Arthrocnemum macrostachyum, Sarcocornia fruticosa, Phragmites australis, Lycium schweinfurthii* and *Tamarix* trees).

4.3.3. Medicinal Use

Fifty-five species are of popular medicinal uses (39% of the total economic species). For example, rhizomes of *Phragmites australis* are stomachic, antiemetic, antipyretic, for acute arthritis, jaundice, pulmonary abscesses, food poisoning, diaphoretic and diuretic. *Alhagi graecorum* is used for treatment of bilharziasis, the boiled leaves of *Emex spinosa* is used for relief of dyspepsia, biliousness and to stimulate appetite. Seeds of *Malva parviflora* are used as a demulcent in coughs and ulcers in the bladder, *Sonchus oleraceus* is reported to be useful in liver troubles, jaundice and as a blood purifier, and *Salsola kali* is used as an anthelmintic, emmenagogic, diuretic and cathartic. Some species are used as appetizer (e.g. *Ammi visnaga, Asparagus stipularis, Centaurea calcitrapa*, and *Ranunculus sceleratus*), astringent (e.g. *Cynomorium coccineum, Cyperus rotundus, Malva parviflora, Plantago major, Tamarix nilotica* and *Tamarix aphylla*), aphrodisiac (e.g. *Asparagus stipularis, Cynomorium coccineum, Cyperus rotundus, Eruca sativa, Paronychia arabica* and *Phoenix dactylifera*), carminative and stimulant (e.g. *Ammi visnaga, Anethum graveolens, Chenopodium ambrosioides, Coriandrum sativum, Cyperus rotundus* and *Mentha longifolia*), and diuretic and stomachic (e.g. *Ammi visnaga, Anethum graveolens, Asparagus stipularis, Centaurea calcitrapa, Chenopodium ambrosioides, Conyza bonariensis, Cynodon dactylon, Cyperus rotundus, Imperata cylindrica, Phragmites australis, Plantago major* and *Portulaca oleracea).*

Phoenix dactylifera is the one of the most important economic species in the Burullus Wetland. Its wood is used as toothbrush, terminal bud "djoummar" is used for intestinal hemorrhage, diarrhea and jaundice. Dates are used internally in medications designed to purge, to clear the enigmatic, or to regulate the urine; in vaginal pessaries. With other ingredients, dates enhance fertility; relieve cough and are flesh-forming. Juice of boiled dates is given to invalids to restore their strength and to assuage thirst. Green dates reputed as aphorodisiac and tonic,

karnels of dates made into cataplasm used against ulcers of genital organs, and ash of kernels used to prepare an eye lotion against blepharitis (after Boulos 1983, Mossa *et al.* 1987).

4.3.4. Human Food

Fruits, flowers, vegetative and under ground parts of thirty-two of the species (22.7% of the total economic species) in this region are eaten by local inhabitants in this region. *Malva parviflora* (khubbayza), *Rumex dentatus* (Hommeid), *Beta vulgaris* (Salque) and *Portulaca oleracea* (rigla) are popular pot herbs. *Sonchus oleraceus* (guded or galawen) and *Cichorium endivia* subsp. *pumilum* (sires or shikurya) are eaten as a salad. The underground parts of *Phragmites australis* and *Typha domingensis* are eaten. The seeds of *Panicum turgidum* are sometimes eaten by the desert dewellers.

4.3.5. Timber

The timber plants are limited allover Egypt. In our region, only 4 species are suitable for this purpose (2.8% of the total economic species). These *are Phoenix dactylifera, Tamarix aphylla, Tamarix nilotica* and *Tamarix tetragyna.*

4.3.6. Other Uses

Thirty-seven species in this region are of several actual or potential uses. The strong fiberous culms or leaves of *Phragmites australis, Cyperus alopecuroides, and Typha domingensis* are used in many parts of the world in the weaving of mats, screens and chair-bottoms; thatching and baskets; and construction of barrels and casks; whilst the fine plush afforded by the hairs of female *Typha* flowers was formerly used in stuffing pillows (Sculthorpe 1985). Other species used for making mats, ropes and baskets include *Juncus acutus, Juncus rigidus* and *Imperata cylindrica.* Some species are used for ornamental purpose (e.g. *Ipomoea* carnea, *Clerodendrum acerbianum*, *Chrysanthemum coronarium* and *Eichhornia crassipes*), and in the manufacture of soap (*Atriplex halimus*). *Azolla filiculoides* is used as a green fertilizer in rice fields and in the production of biogas (FAO 1979). Some other species were used in the treating of waste water (e.g. *Phragmites australis, Lemna* spp. and *Eichhornia crassipes*).

4.4. REED BEDS (*PHRAGMITES AUSTRALIS*)

4.4.1. Spatial and Temporal Variations

Common reed '*Phragmites australis* (Cav.) Trin. ex Steud.' is believed to be the most widely distributed of all angiosperms. Although a native of the old world tropics, it is remarkable for being equally at home in the countries of the northern temperate zone and in the torrid swamps of the Nile. Although the common reed threatens water ways, pastures, and arable fields, but it has many uses. It is used as shelter, wind break, thatch, forage and refuge for animals, fuel, fertilizer, for making crafts, mats, baskets, and raw material for paper industry (Holm *et al.* 1977, see also Zahran & Willis 2003) and its rhizome is reported in folk medicine (Boulos 1983). It plays also an important environmental role in the remediation of the polluted water (Schierup *et al.* 1990).

Reed beds of Lake Burullus represent one of the most important reed beds in the Mediterranean region, where this type of habitat is becoming rare and threatened. The reed stands along the shores of this lake and around its islets represent the most common vegetation type (Shaltout and Al-Sodany 2000). Wintering and migrant birds are strongly dependent on this habitat for foraging, refuge and breeding; thus Lake Burullus was registered as one of the sites of Ramsar Convention (Kassas 2002). The reed beds also create a suitable shelter for the fishes of this lake (approx. 52000 ton/yr: census of 2000), particularly fry and juveniles (Khalil and El-Dawy 2002).

The study of Shaltout *et al.* (2004) indicated that the temporal variation in the shoot height and weight of *Phragmites australis* in Lake Burullus had a gradual increase from June (2.9 ± 0.2 m/shoot and 18.5 ± 2.0 g/shoot) to October (3.4 ± 0.2 m/shoot and 40.7 ± 8.6 g/shoot), while the variation in shoot density indicated a reverse trend (134.7 ± 8.3 shoot/m^2 in June and 98.0 ± 9.6 shoot/m^2 in October). On the other hand, the spatial variation indicated that the shoot height and density were smaller, while the shoot weight was higher in the north than in the middle and south of the lake (Table 4.17). The standing-crop phytomass was the highest at the end of the season (2.9 ± 0.4 kg/m^2), and at the south of the lake (3.3 ± 0.5 kg/m^2). The shoot height had significant positive correlations with the shoot weight and standing–crop phytomass. On the other hand, the shoot density had significant negative correlation with the shoot weight, and significant positive correlation with the standing–crop phytomass (Fig. 4.9).

Table 4.17. **Temporal and spatial variation in growth variables of common reed (*Phragmites australis*) in Lake Burullus. *: P= 0.05, **: P = 0.01 and ***: P = 0.001 according to two-way analysis of variance. F_t: F time, F_s: F section.**

Section	Month			
	Jun.	Aug.	Oct.	Mean
a- Height (m shoot^{-1}). F_t = 1.57, F_s = 0.30, $F_{t\,x\,s}$ = 0.16				
North	2.9 ± 0.3	3.0 ± 0.4	3.2 ± 0.4	3.0 ± 0.2
Middle	2.9 ± 0.3	2.9 ± 0.4	3.3 ± 0.5	3.0 ± 0.2
South	2.9 ± 0.3	3.2 ± 0.4	3.7 ± 0.4	3.2 ± 0.2
Total mean	**2.9 ± 0.2**	**3.0 ± 0.2**	**3.4 ± 0.2**	**3.1 ± 0.1**
b- Density (shoot m^{-2}). F_t = 4.20*, F_s = 3.03*, $F_{t\,x\,s}$ = 0.27				
North	117.6 ± 14.6	95.7 ± 10.8	88.3 ± 16.0	103.0 ± 8.4
Middle	137.9 ± 11.6	100.5 ± 13.7	102.0 ± 16.3	120.1 ± 8.3
South	154.2 ± 16.5	135.7 ± 23.8	105.0 ± 17.8	132.2 ± 11.5
Total mean	134.7 ± 8.3	111.9 ± 10.6	98.0 ± 9.6	117.7 ± 5.6
c- Shoot weight (g shoot^{-1}). F_t = 5.15*, F_s = 0.84, $F_{t\,x\,s}$ = 0.51**				
North	19.1 ± 3.8	33.1 ± 6.8	50.2 ± 22.0	32.0 ± 6.9
Middle	15.4 ± 2.4	28.7 ± 6.6	29.0 ± 6.2	22.0 ± 2.7
South	21.6 ± 4.4	20.9 ± 6.3	38.8 ± 6.7	27.0 ± 3.5
Total mean	18.5 ± 2.0	27.4 ± 3.9	40.7 ± 8.6	27.4 ± 2.9
d- Standing crop phytomass (kg m^{-2}). F_t = 0.53, F_s = 2.04, $F_{t\,x\,s}$ = 0.30				
North	2.1 ± 0.4	2.7 ± 0.6	2.4 ± 0.7	2.4 ± 0.3
Middle	2.1 ± 0.3	2.8 ± 0.6	2.6 ± 0.5	2.5 ± 0.3
South	3.4 ± 0.8	2.9 ± 0.9	3.6 ± 0.7	3.3 ± 0.5
Total mean	2.5 ± 0.3	2.8 ± 0.4	2.9 ± 0.4	2.7 ± 0.2

4.4.2. Water Characteristics

The temporal variation in the water characteristics indicated that many of the estimated characters, particularly the dissolved salts and heavy metals, were higher at the end of the season in October than in June and/or August. Regarding the spatial variability, the water depth and salinity at the north were higher than those at the south. On the other hand, oxygen demands, dissolved salts and heavy metals were higher at the south than the north (Table 4.18). The correlation between the density of *Phragmites australis* and water alkalinity was significantly positive, while the correlations between the density and heavy metals (Cu, Fe and Pb) were significantly negative (Table 4.19). Shoot weight had significantly negative correlation with water pH, while standing–crop phytomass had significantly positive correlation with water alkalinity.

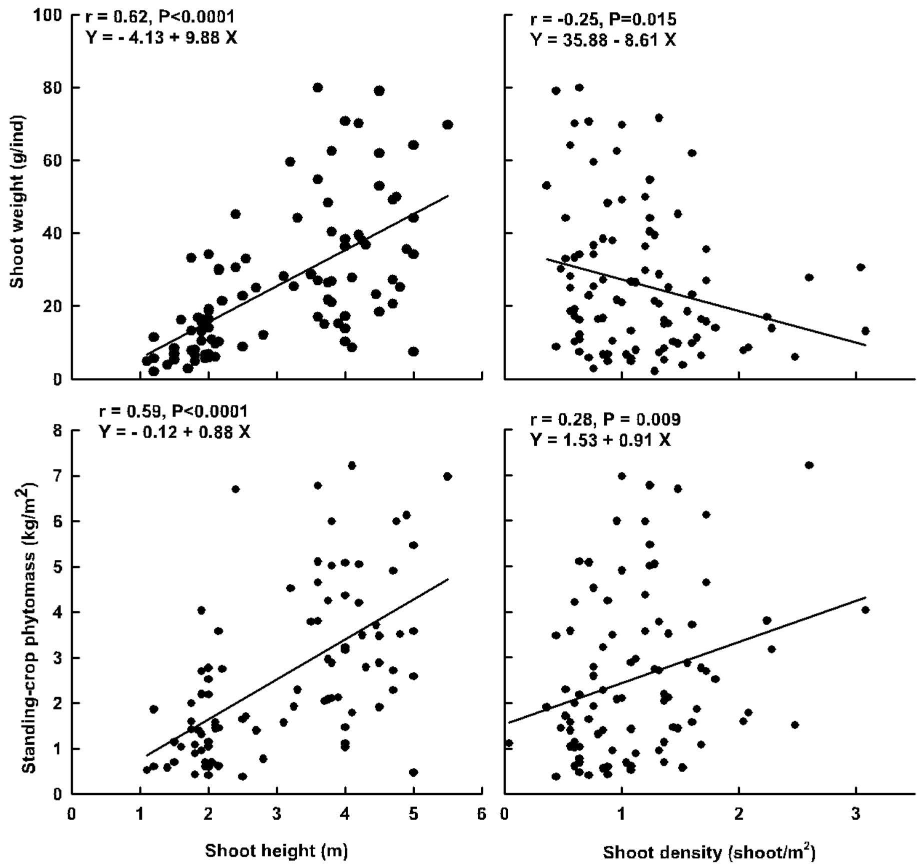


Fig. 4.11. **The relationship between the shoot height and density, and the shoot weight and standing-crop phytomass of Phragmites australis in Lake Burullus.**

Table 4.18. **Temporal and spatial variation in the mean water characteristics of Lake Burullus*: P = 0.05, **: P = 0.01, ***: P = 0.001 according to one-way analysis of variance. DO: dissolved oxygen, COD: chemical oxygen demand, BOD: biological oxygen demand.**

Variable		Mean ± SE	Section			F-value	Month			F-value
			North	Middle	South		Jun.	Aug.	Oct.	
Physical and aggregate properties										
Water depth (cm)		124.4 ± 5.0	142.9	115.3	119.7	1.4	121.0	112.3	140.0	1.5
Transparency (cm)		34.4± 0.9	40.4	37.2	28.1	9.7***	29.7	33.7	40.0	5.4**
EC (mS cm^{-1})		5.2± 0.3	6.0	4.9	4.9	0.3	5.5	5.6	4.5	0.4
pH		8.8± 0.1	8.7	8.9	8.8	2.0	9.0	8.9	8.7	3.1*
Chloristy (g l^{-1})		1.9± 0.1	2.2	1.7	1.9	0.3	2.0	2.0	1.8	0.1
Alkalinity (mg l-1)		273± 4.9	251.0	275.9	285.3	1.9	266.1	273.3	279.6	0.3
Oxygen properties										
DO	**mg l^{-1}**	8.0±0.3	8.7	7.7	7.9	1.1	8.3	7.5	8.3	0.8
COD		5.3±0.2	5.4	4.8	5.7	1.5	5.5	6.4	4.0	12.9***
BOD		4.0±0.3	3.8	3.8	4.4	0.5	4.2	5.4	2.6	15.1***
Dissolved salts										
PO_4	**µg l^{-1}**	1.3±0.1	0.7	1.2	1.8	9.6***	0.9	1.4	1.5	2.0
NO_3		2.3±0.2	1.3	2.1	3.1	11***	2.0	2.1	2.7	1.3
NO_2		1.2±0.1	0.8	0.9	1.6	4.7**	1.3	1.4	0.9	2.0
SiO_3		21.9±1.0	26.1	21.9	19.1	1.4	19.5	21.6	24.6	0.8
Heavy metals										
Cu	**µg l^{-1}**	4.5±0.2	3.5	3.7	5.2	3.6*	3.8	3.5	5.4	4.1*
Fe		1.3±0.1	1.3	0.9	1.6	1.1	0.7	0.8	2.6	21.7***
Cd		2.3±0.2	2.3	2.1	2.4	0.2	1.8	1.7	3.3	5.9***
Pb		1.5±0.1	1.0	1.5	1.9	2.2	1.2	1.2	2.3	4.3*
Zn		5.2±0.2	6.0	4.8	4.9	0.8	4.4	4.5	6.6	3.1*

The inspection of the 1988 and 1998 LandSat TM images indicated that the heavy growth of reed was around the scattered islets and close to the outermost south-eastern shore of the lake (Fig. 4.10). Moreover, at the outermost west side, the reed invaded the narrow course that separates the north and south shores.

On the other hand, the analysis of these images indicated that the area of the lake had decreased from 46876 ha in 1988 to 42000 ha in 1998 (reduction = 10.4%). In the meantime, the area of the common reed had decreased during the same period from 10416 ha to 6972 ha (reduction = 33.1%). On the other hand, the ratio of reed area to lake area had decreased from 22.2% to 16.6% (Table 4.20). The maximum standing-crop phytomass of the common reed in the lake as a whole was estimated as 202188 ton dry matter; of which 146412 ton represents the above water standing-crop phytomass and 55776 ton represents the submerged portion (Table 4.21).

Table 4.19. **Pearson's simple linear correlation coefficients (r) between the water variables and the population variables of common reed (*Phragmites australis*). *: P= 0.05, **: P = 0.01 and ***: P = 0.001 according to one-way analysis of variance. COD: chemical oxygen demand, BOD: biological oxygen demand.**

Variable	Mean	Month		
		July	August	October
Shoot height (m)				
COD	0.66	- 0.52	0.92***	0.61
BOD	0.49	- 0.52	0.89**	0.82**
PO_4	0.13	- 0.82**	- 0.24	0.78*
NO_3	0.31	- 0.22	0.31	0.74*
NO_2	0.51	- 0.29	0.62	0.78*
Cu	0.64	- 0.84**	0.76*	0.51
Pb	0.57	- 0.89**	0.63	0.58
Density (shoot m^{-2})				
Alkalinity	0.76*	0.68	0.70*	0.52
Cu	- 0.73*	- 0.39	- 0.76*	- 0.74*
Fe	- 0.79*	- 0.73*	- 0.87*	- 0.64
Pb	- 0.69*	- 0.28	- 0.66	- 0.70*
Shoot weight (g individual^{-1})				
Transparency	- 0.11	0.86**	0.09	0.06
pH	- 0.69*	- 0.17	- 0.65	- 0.45
NO_2	0.16	0.05	0.75*	- 0.51
Cu	0.22	- 0.31	0.70*	0.08
Fe	0.16	- 0.04	0.72*	- 0.02
Phytomass (g / m^{-2})				
Transparency	-0.86**	- 0.35	- 0.15	- 0.87**
Alkalinity	0.72*	0.71*	- 0.29	0.16
COD	0.31	- 0.32	0.78*	0.13
NO_2	- 0.01	- 0.57	0.54	0.71*
Fe	- 0.54	- 0.78*	0.39	- 0.55

In general, the shoot height and the shoot weight of this plant increased with time, while its density decreased. As the plants in a dense population, such as Phragmites australis, become larger with age, the density of individuals in the population decreases due to mortality (Silvertown 1987). In the meantime, its standing-crop phytomass increased with time, due to the faster increase in plant weight compared with the falling of its density. This process is called self thinning due to density-dependent mortality, and could be explained as a competitive phenomenon (Weiner 1985).

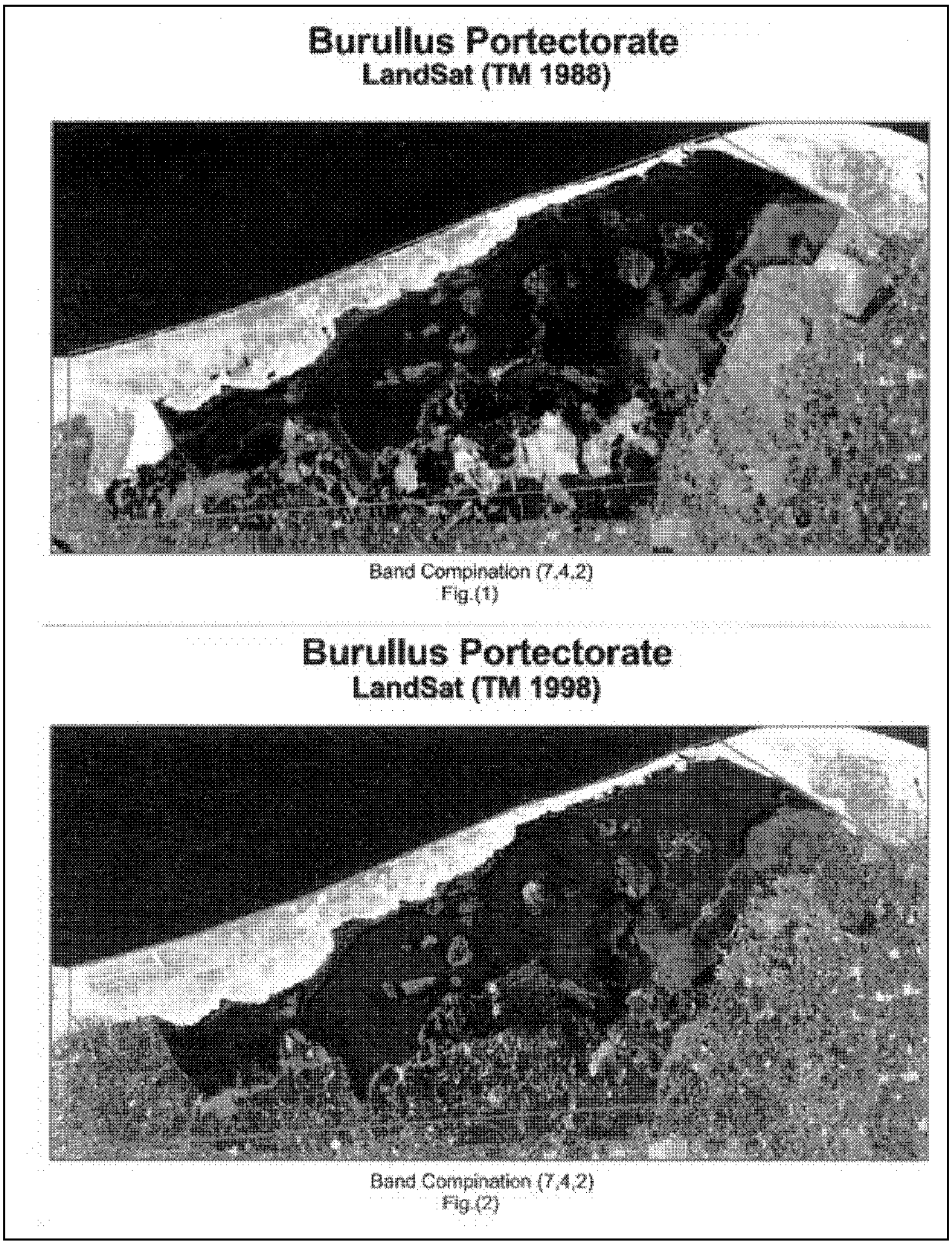


Fig. 4.12. LandSat TM images of Lake Burullus indicating the changes in the areas of the lake and common reed (*Phragmites australis*) during 1988 and 1998.

Table 4.20. **Change in the area of Lake Burullus and area colonized by common reed (*Phragmites australis*) during the period from 1988 to 1998.**

Area (ha)	1988	1998	Reduction	
			Actual (ha)	%
Lake area	46876	42000	4875	10.4
Reed area	10416	6972	3444	33.1
Reed: Lake ratio (%)	**22.2**	**16.6**	**70.6**	**318.3**

Table 4.21. **Maximum standing-crop phytomass of common reed (*Phragmites australis*) in Lake Burullus.**

Phytomass component	kg / m^2	Ton / ha	Ton / lake
Above rhizome	2.9 ± 0.4	29.0 ± 4.0	202188
Above water	2.1 ± 0.3	21.0 ± 3.0	146412
Submerged portion	0.8 ± 0.1	8.0 ± 1.0	55776

Shaltout *et al.* (2004) reported that the shoot height, density and standing-crop phytomass of *Phragmites australis* were higher in the south of the lake than its north. One of the possible causes is the relatively high water salinity in the north of the lake which is connected with the Mediterranean Sea through a sea outlet. The adverse effect of increasing salinity on the growth variables of this plant is reported also by Hellings and Gallagher (1992). The relatively deep water in the north compared with the south may also be another factor that adversely affects its growth. As indicated by Mauchamp *et al.* (2001), young *Phragmites australis* plants require shallow water levels without long lasting submergence to grow and survive; tolerance to submergence increases with age. The high eutrophication in the south, due to the drainage of the agricultural, municipal and industrial water (El-Shinnawy 2002), may also be among the factors responsible for the heavy growth of *Phragmites australis* in this section.

The decrease in the area of Lake Burullus during only one decade (1988 – 1998) by approximately 10% is mainly due to reclamation of about 5000 ha from its western fringes for agriculture. Such severe activity probably had been ceased nowadays after declaring the lake as a natural reserve in 1998 (Kassas *et al.* 2002). On the other hand, the area of common reed decreased by a ratio of 0.33 during the same period. If this rate is continued, this means that all of the reed area in Lake Burullus will be eliminated within the next few decades (Shaltout *et al.* 2004). However, the management of common reed in Lake Burullus should include the periodical partial removal of the reed between the islets, in order to avoid the

future connection between them and hence the probable fragmentation of the lake into four disconnected basins. The same maintenance should be carried out at the outermost west side in order to avoid the probable closing of the narrow course that feeds this part of the lake. On the other hand, the reed harvesting for the commercial purpose should be carried out in the south-eastern part in order to cease the hydrach succession that often leads to the silting of the water bodies.

In an experimental study on the productive capacity of *Phragmites australis*, Batterson and Hall (1983) reported a value of 95 ton dry weight/ha. This approaches the reported values for water hyacinth which is claimed to be the highest yielding plant in the world. It is interesting to indicate that this high yield is only for the above-ground parts of the plant which probably constitutes only 25% of the total phytomass. In case of *Phragmites australis* in Lake Burullus, the maximum above-ground phytomass at the end of the season in October approaches 29 ton dry weight/ha. Under the Egyptian wetland conditions, the above-ground standing-crop phytomass of this plant ranges between 11 and 46 ton dry weight/ha (see Abu Ziada 1987, Khedr 1989, Batanouny *et al.* 1991, Serag 1991, El-Kady 2000). This means that the above-ground standing-crop phytomass of this reed in Lake Burullus lies at a medium position along its production scale in Egypt.

Although the drying-up of the western end of Lake Burullus is partially responsible for the retreating of *Phragmites australis* during 1988 – 1998, but other factors seem to be effective. The expanding of agriculture, industry and human population in the catchement area of this lake (approximately 5000 km^2: El-Shinnawy 2002), as well as the increased use of chemical fertilizers and pesticides may exert an adverse influence on the water characteristics and associated biota of the lake. But the results of the water analysis do not support this assumption. Most of the estimated water characteristics do not exceed the permissible limits (see Moss 1988), thus it is not considered a highly polluted or a highly eutrophic lake. The human over-uses in Lake Burullus as a result of the increased human population (e.g. the over-cutting for the animal feeding, thatching, fencing and mat making) may be among the effective factors that lead to the retreat of the reed beds in this lake. The burning of reed by fishermen during the winter, for increasing the fish catching, has an adverse effect on the reed area and reed standing-crop.

In general, the reduction of reed area by about one-third of its original area during only one decade (1988 – 1998), coupled with the relatively low production may suggest that the population of common reed in Lake Burullus is a retreating,

not an expanding population. If the factors that led to this high rate of retreating continue, the whole population may be eliminated during the next few decades.

4.4.3. Nutritive Values

Shaltout *et al.* (2002) reported that the macroelements were higher in the green parts of *Phragmites australis* than in the dry ones, but the reverse is true regarding the microelements (i.e. heavy metals). The element contents of both the green and dry parts of the shoots of common reed are within the mineral range in feeds commonly used in rations of sheep, goat and cattle (NRC 1975, 1978, 1981 and 1984), and none of these elements exceeds the maximum tolerable level for cattle (NRC 1984), except Mg (the maximum tolerable level is 0.40%, compared with a range of 0.47 – 0.51% in the green and dry parts of common reed) and Pb (the maximum tolerable level is 30 ppm, compared with a range of 66.5 – 75.10 ppm in the green and dry parts of common reed). The general trend of macroelements is K > Na > Ca > N > Mg > Fe > P, and that of microelements is Zn > Mn > Pb > Cu > Co (Table 4.22). The green parts had higher contents of the organic components than the dry ones (except the crude fiber). Regarding the net energy, the green and dry parts of *Phragmites australis* in all cases (except spring where the green parts are ranked under excellent quality) were ranked under good quality fodder acording to the forage quality table of Boudet and Riviere (1968).

Regarding the digestible protein, the green parts only were ranked under the good quality during spring and autumn (4.03 and 3.70%, respectively). In general, the organic components and nutritive values of green parts are within the ranges in the feeds commonly used in rations of sheep, goat and cattle (NRC 1975, 1978, 1981 and 1984).

4.4.4. Economic Uses

Environmentally, the common reed (*Phragmites australis*) may serve as an excellent soil binder to prevent erosion and washouts. For many years this plant was used only for peasant crafts, thatching and windbreaks. Nowadays, most of the phytomass of this plant in the Danube Delta (Romania) was turned into pulp for the production of printing paper. Other products are cemented reed blocks, cardboard, cellophane, synthetic fibers, furfural, alcohol, fuel, insulation materials, and fertilizer. The annual harvest amounts to hundreds of thousands of tons, so that the reeds of this delta have become an important component of the Romanian economy (Holm *et al.* 1977).

Table 4.22. **Mean concentration (average of spring and summer estimations) of the different nutrients of the green and dry parts of common reed shoots (*Phragmites australis*) in Lake Burullus.**

Element	**Green**	**Dry**	**Total**
Macroelements (%)			
Na	0.77	1.03	1.79
K	2.04	1.06	3.10
Ca	0.99	0.75	1.74
Fe	0.03	0.07	0.10
Mg	0.51	0.47	0.98
P	0.02	0.01	0.03
N	0.99	0.40	1.40
Total	**5.35**	**3.78**	**9.126**
Microelements (ppm)			
Cu	17.65	18.30	35.95
Mn	90.45	91.75	182.20
Zn	41.45	154.05	195.50
Pb	66.50	75.10	141.60
Co	8.95	5.35	14.30
Total	**225.00**	**344.55**	**569.55**
Organic component (%)			
Total carbohydrate	50.66	47.18	97.84
Total protein	6.29	2.51	8.80
Ether extract	2.28	1.66	3.94
Crude fiber	29.28	38.09	67.37
Ash	11.48	11.19	22.66
Total	**99.99**	**100.62**	**200.60**
Digestible crude protein (%)	2.37	0.16	2.52
Total digestible nutrients (%)	62.16	56.25	118.41
Digestible energy (Mcal kg^{-1})	2.48	2.19	4.67
Metabolized energy (Mcal kg^{-1})	2.04	1.80	3.84
Net energy (Mcal kg^{-1})	1.02	0.90	1.91
Gross energy (Kcal 100mg^{-1})	401.75	400.20	801.95

The Dutch authorities devised a way to secure new polders against perennial weed problems by planting the area with *Phragmites australis*. The serious weeds were successfully kept under control by competition from the reed until finally, when the land was tilled and drained, *Phragmites australis* was eliminated. In the meantime, the reed had promoted the aeration and permeability of the soils (Holm *et al.* 1977).

It is well known that the common reed is an important refuge for wildlife. Its vegetative parts provide shade, shelter, and food for fish and the seeds provide food for some waterfowls. The vegetative parts are also eaten by cattle, sheep and goats, and are very important food for muskrats and pigs in some areas. It is usually satisfactory as fodder only when young.

Common reed was an important source of matting in ancient Egypt and is widely used for this purpose today. Also, it is important in the horticultural trade for mats, shading, and containers in the Netherlands. It is plaited into sandals, the culms are carved into writing pens, it makes excellent thatch, and it is an important raw material in papermaking. Its rhizome is reported in folk medicine as stomachic, antiemetic and antipyretic; for acute arthritis, jaundice, pulmonary abscesses, food poisoning, diaphoretic, and diuretic (Boulos 1983).

Recently, international attention has been directed towards the capacity of constructed reed wetlands as a phytoremediation to control water pollution and to treat municipal and industrial wastewater (Gersberg *et al.* 1986, Cooper and Boon 1987, Brix and Schierup 1989, Jackson 1989, Cooper and Hobson 1989, May *et al.* 1990, Schierup *et al.* 1990 and Williams *et al.* 1994). In this case, *Phragmites australis* is an ideal candidate because it can form deep roots and hollow rhizomes supporting a great volume of active rhizosphere. Leakage of oxygen from the roots may create oxidized microzones that remove organic and suspended solids as well as nitrogen and phosphorus from wastewater (Brix and Schierup 1989). This supports the suggestion indicated that aquatic macrophytes in general, and *Phragmites australis* in particular, are of importance in water purification (see Zahran & Willis 2003).

4.4.5. Control Techniques

Like any other weed pest, *Phragmites australis* seedling can be controlled by normal cultivation. Unlike most weeds, once established, *Phragmites* has an underground storage system for reproduction (i.e. rhizomes). The rhizomes contain buds or eyes that can grow to form more reeds. In this process, the energy stored in the rhizome is temporarily depleted until the reed has sufficient green leaves to manufacture new energy reserves for storage below ground. Any control measures must be aimed at the depletion or destruction of energy reserve in the massive underground system of *Phragmites*, not just destruction of the reed itself (Serag 1991).

4.4.5.1. Mechanical control

Deep ploughing followed by rotary hoeing can destroy much of the root system; this process can be applied using amphibian machines. Cultivation encourages new growth and a reduction in root energy reserves. With the rapid improvement in field surface drainage, the potential for partial control by cultivation is increasing. However, total eradication is difficult as much of the root system is below cultivation depth. The cutting below the water level is also efficient for controlling the reeds and sedges in wetlands. The effectiveness of the cutting below water is due to prevention of the gaseous diffusion of oxygen down to the roots and rhizomes. When roots and rhizomes are deprived of aerial connections, they quickly used all oxygen supplies and began respiring anaerobically producing ethanol. In all cases, the cuts of the plant should be thrown out the aquatic body.

4.4.5.2. Chemical control

The herbicides Dalapon and Glyphosate are the most reliable. It has shown that Dalapon applied in two applications of 5 kg ha^{-1} gives fast, and short term control. Glyphosate applied in two applications of 2 liters ha^{-1} gives low but long term control. The longer the reeds can remain uncultivated after spraying, the better the control will be. However it is not recommended to apply the chemical control in the water bodies of high fish production such as the case of Lake Burullus of approximately 50000 ton of fish per year.

4.5 MANAGEMENT PRACTICES

Sustainable management strategy of the floral biodiversity in Burullus Wetland requires some activities such as stopping the severe human impacts that lead, gradually in some cases and suddenly in some others, to eliminate certain plant populations and hence the modification of the complex plant communities into simple fragile ones. The human impacts in this region take the following activities: continuation of the land reclamation of the expense of natural habitats particularly the salt marshes and sand formations, severe change of the water characteristics of the Lake due to discharge of fish-farming, agricultural, industrial and domestic solid and liquid wastes, and fragmentation or even removal of the natural habitats, particularly the sand formations and salt marshes that occur in the sand bar and on some islets.

Management of reedbeds (e.g. common reed: *Phragmites australis*) in the form of regulating their cutting process is urgent near the mouths of the drains and the Lake shores. This process is also urgent to maintain small canals that connect

all the water bodies of the Lake for preventing their fragmentation. Also, controlling the growth of water hyacinth (*Eichhornia crassipes*), that has been starting to invade severely the water body of the Lake, is highly recommended.

Carrying out many educational and training programs for raising the public awareness about the importance of Lake Burullus as a natural reserve for hundreds of biota and the sustainable use of their resources is highly important. This can take many forms including training courses, general lectures, episodes in the local radio and TV, field trips for the students of the secondary and high education and employees of the related authorities. It is also recommended to declare some areas in Burullus Wetland as managed nature reserve for the conservation of the rare species. Based on the available data, it is suggested the following areas: El-Kawm Al-Akhdar and Dechimi islets with an aquatic belt of at least 250 m width for each one of them, and the whole sand bar that separates between the Lake and the Mediterranean, which includes the most threatened habitats (e.g. sand formations) and many of the species that are highly threatened along the whole Mediterranean coast of Egypt.

It is important to carry out a long term monitoring system for the endemic, rare and noteworthy species. This will help in any management plan for conserving the threatened species and controlling the growth of the invasive ones. Preventing the navigation with motor propellers, except for the Police Force and other public authorities, is also an important action.

4.6. ANCIENT FLORA AND VEGETATION

4.6.1. Autochtonous Associations

Autochtonous palyonomorphs reflect the types of vegetation flourishing in the area of the borehole and the environmental conditions prevailing during the sedimentation of the Nile alluvium at different depths. The pollen analysis of soil samples collected from a borehole close to the Burullus Wetland (Brimbal) revealed that common pollen grains which constitute more than 90% of autochtonous palynomorphs are those related to the families: Gramineae, Cyperaceae, Compositae and Chenopodiaceae. Of minor importance are those related to: Liliaceae, Polygonaceae, Leguminosae and Plantaginaceae (Table 4.23, after Saad and Sami 1967). The analysis also indicated that the pollen grains of the first five families were grouped together in the different horizons in varaible percentages indicating climatic changes in temperature and humidity (see Zahran & Willis 1992).

Table 4.23. **The counts (per 10 slides for each sample) of the different types of allochtonous and autochtonous sporomorphs in the borehole of Brimbal at the south-western part of Lake Burullus (after Saad and Sami 1967).**

Depth (m)	Allochtonous types					Autochtomous Types																			Other types	Total
	Spores		Pollen				Pollen																			
			Gymnospermae	Angiospermae		Spores	Gymnospermae	Angiosperms																		
								Monocotyledons				Dicotyledons														
	Trilete spores	Monolete spores	Podocarpus	Combretaceae	Ericaceae	Monolete spores	Pinus	Gramineae	Cyperaceae	Typhaceae	Liliaceae	Chenopodiaceae	Compositae	Caryophyllaceae	Umbelliferae	Tamaricaceae	Leguminosae	Polygonaceae	Euphorbiaceae	Oenotheraceae	Plantaginaceae	Betulaceae	Ulmaceae	Moraceae		
surface	102	2	3	4	1			44	41		2	17	109	1	3	1	1		8		2				14	355
1	43	1		1			1	31	10	1	1	11	27		2	4	1		6						20	160
2	69	1	8	2		2		88	75		3	3	18	2		2	3		2		1				43	322
11	125		8			27		174	86	1	2	19	17	1		4									12	474
12	34	1				4		102	132		1	12	17	1	5	1			1						4	414
13	27	1	1			6		69	112		2	11	3	11	3	2	1	1							12	262
14	264	2	42	2		46		208	191		33	60	78	9	11	22	17		4		2	1	1	3	48	1044
18	136	1	9	3	1	51	1	218	657	28	3	70	113		5	7	4	1	2	4	1	1			33	1349
19	36	4	5			8	2	389	762	70	1	85	49	1	4	3			1	2	2				15	1439
20	3					103		61	835	10		8	53					1		1						1056
21						5		8	233	1		2	6													255
27	16	1	1			7		26	35	4		3	1	1	8			27								130
28	35	3				58		122	90	6	2	44	13		23	2		2							6	406
29	21	2	1			68		145	256	1	1	45	17		25	3		2		1					17	605
30	3							10	17			6	1		8											45
31-37																										

The pollen counts the grass and sedge families (i.e. Gramineae and Cyperaceae) reflected the extent of the marshes, because of the great amount of pollen produced by members of these families. They are highly over-represented in comparison to other hydrophytic plants like *Nymphaea, Jussieua* and *Typha*. On the other hand, the pollen counts of Chenopodiaceae show typical dry halophytic vegetation. On the other hand, the rise in the Compositae and *Ephedra* counts pollen shows a dry and warmer climate. Peaks of Umbelliferae, Cruciferae and Leguminosae pointed to a humid somewhat cold climate as these plants seem to favour wet cold climate conditions (Saad and Sami 1967).

Generally, speaking most of the alluvium samples are poor in tree pollen (0.3% of the total sporomorphs). Some of these trees are no doubt autochtonous like *Tamarix* and *Acacia*. The pollen frequencies of these trees at the different depths of the Berembal borehole are given in Table 4.24 (after Botros 1978).

***Table 4.24.* Counts of autochtonous tree pollen (polyad / 3 gm) at different depths of the Berembal borehole (after Botros 1978).**

Depth (m)	*Tamarix*	*Acacia*	*Betula*	*Alnus*	*Pinus*	*Ulmus*
Surface	1					
1	4	1			1	
2	2	3				
11	4					
12	1					
13	2	1				
14	22	9	1	1		1
18	7	2	1	1	1	
19	3				2	
28	2					
29	3					

The pollen of *Tamarix* are present in most samples from soil surface down to 29 m deep, with a maximum count at the depth of 14 m. This means that the growing of *Tamarix* trees are dated to 17000 years B.P. Pollen grains of this tree were recorded from the Pleistocene of Egypt. Pollen analysis shows that pollen grains of *Tamarix* are more frequent on the southern and north western Delta (Berembal) than on its other sides (Botros 1978). The most frequent species are *Tamarix articulata* Vahl and *Tamarix nilotica* (Ehrenb.) Burge. These trees are adapted to salty and sandy soils. They are suitable for planting in the desert and

on the Mediterranean coast. The second species is found along the Nile and canal banks.

Next in importance are the pollen of *Acacia* (one of the most common native trees). Its pollen grains are met with in many samples from the 1 m depth till the depth of 18 m indicating that *Acacia* trees have been growing in the Delta for nearly 10000 years. Maximum count was at the depth of 14 m (Table 4.24).

Pollen grains of *Betula* and *Alnus* (Betulaceae) have been recorded at Berembal borehole. These trees are very old and mostly grow in the northern hemisphere. They are economically important for the hard wood lumber. For reasons given in Botros (1978), both trees are considered autochtonous, although they are not recorded in the recent flora of Egypt (see Boulos 1995). They may have grown in the Delta during cold climates but disappeared when it turned hot, or may have been carried from the Nubian region as its fossil pollen were recorded from Kurkur Oasis (Van Campo *et al.* 1968). In addition, a number of *Pinus* pollen were recorded from three depths (1, 14 and 18 m). These pollens are most probably of local origin or they may have been carried by the wind from neighbouring countries (i.e. allochtonous).

4.6.2. Allochtonous Associations

Allochtonous polynomorphs reflect the types of vegetation flourishing around the regions of the Nile water sources. Their quantities in the different samples may give relative measures of the Nile flood, during which these alluvia were deposited. The most frequent allochtonous sporomorphs in the samples are related to *Podocarpus* pollen, trilete and monolete spores. They constitute more than 90% of the total allochtonous palynomorphs. *Podocarpus* grows on the mountains of Ethiopia at the height of 3200 m (Hedberg 1951) and is carried by the River Nile. In addition to other allochtonous sporomorphs, the presence of pollen grains of *Podocarpus* in the Egyptian deposits, is taken as the principal indicator of Ethiopian origin,. These small bladdered pollen have good buoyancy, enabling them to travel such a long way to reach Palestine's shores (Rossignol, as quoted by Botros 1978).

4.6.3. Plant Succession

The ancient plant succession in Burullus Wetland may have happened as follows: before the time the soil at 30 m deep had been deposited, this region was part of the sea. After that, regression of the sea took place and the Nile water began to reach this area; xerophytes, hydrophytes and helophytes appeared and limited lagoons were formed. Nearly 20000 years ago, blocking of the Nile took place (Fairbridge 1962), but there was

tremendous rainfall, on northern Egypt. Consequently, swamps covered by *Cyperus papyrus* had spreaded allover the area. Cold seasons probably followed, as indicated by the appearance of *Betula* and *Ulnus* pollen in the samples at 14 and 18 m deep. After that, rainfall had decreased and swamps become limited, this was probably due to more deposition of transported matter by the Nile during erosion stage. Consequently, terresterial plants began to flourish; and oscillations in the Nile run-off and the richness of the wild plants, with a rise in the sea level, took place. This was, probably, due to changes in solar radiation. The last picture was retreating of swamps and stabilization of land cultivation, as a result of continuous siltation (Saad and Sami 1967).

4.7. SUMMARY

Burullus Wetland includes 10 types of habitat (sand formations, salt marshes, lake cuts, terraces, slopes, water edges and open waters of the drains, islets, shores and open waters of the lake). Each one of these habitats has some unique species (species solely found in one habitat). From the floristic biodiversity viewpoint, the most important habitats are the lake islets (26 unique species), sand formations and salt marshes (12 species for each of them).

The total number of the vascular plant species recorded in Burullus Wetland was 197 species (100 annuals and 97 perennials) belonging to 44 families and 139 genera. Twelve of these species are floated and submerged hydrophytes contributing about 6% of the total species. On the other hand, 34 species are woody plants contributing about 17.3 % of the total species (11 phanerophytes and 23 chamaephytes). Three species are endemic to Egypt (two annuals: *Sinapis arvensis* subsp. *allionii* and *Sonchus macrocarpus*, and: one perennial: *Zygophyllum album* var. *album*). Three other species are not found else where in Egypt except Nile Delta (*Ipomoea carnea, Vossia cuspidata* and *Ranunculus marginatus*). On the other hand, thirty-four species are rares allover Egypt (15 annuals and 19 perennials).

The application of Shannon diversity index, that evaluates the relative evenness of species dominance, indicated that Lake Burullus, which has the second largest area after Lake Manzala, had the highest species relative evenness of species, followed by Mariut, Manzala, Bardawil and Edku Lakes.

One hundred and forty one of the recorded species in Burullus Wetland (> 7.5 % of the total species) have at least one aspect of economic uses such as grazing, fuel, medicine, human food, timber and traditional industries. Ten species of them have at least 4 economic uses and could be considered as noteworthy multipurpose species.

The vegetation in the Burullus Wetland is classified into 13 vegetation groups (i.e. plant communities). Six groups are dominated or codominated with the common reed (*Phragmites australis*); these groups occupy a wide gradient from xeric to hydric habitats. Other five groups are dominated by halophytic species (*Arthrocnemum macrostachyum, Suaeda vera, Sarcocornia fruticosa, Halocnemum strobilaceum* and *Salsola kali*). The remaining two groups are dominated by the emergent *Typha domingensis* and submergant *Potamogeton pectinatus*.

From the floristic biodiversity viewpoint, we can conclude that the site of Burullus Wetland is considered as one of the richest sites in Egypt, taking into account its relatively small area (approximately 410 km^2). For example its flora approximates 40% of the flora of the whole Nile Delta region that has an area of about 22,000 km^2, and exceeds those of many of the Egyptian nature reserves such as Nabq (600 km^2: 134 species) and Wadi Al-Allaqui (20,000 km^2: 92 species).

Globally Common reed (*Phragmites australis*) is believed to be the most widely distributed of all angiosperms. It is a perennial reed with broad and flat leaf blades and large terminal panicles. It reproduces from vegetative propagules and has a vigorous, branched rhizome system that runs quickly to new areas in either the submerged or dry lands. This plant threatens man's waterways, pastures and arable fields, but it can be a helpful companion. It provides shelter, material for thatching, food for animals, chemicals, fuel, fertilizer, biofilter, and raw material for paper making industry.

The trends of the estimation of standing crop phytomass (gm dry matter/m^2) of the above rhizome and above water shoots of this plant in Lake Burullus indicated higher values at the end of the season (in October), and at the east and south sides of the Lake comparing with the west and north sides. The analysis of Landsat TM images (1988 and 1998) indicated that the area of the Lake had decreased from 111608 feddan (=46876 ha) in 1988 to 100000 feddan (=42000 ha) in 1998 (reductions rate = 10.4 %). In the meantime, the area occupied by common reed had decreased from 24800 feddan (=10416 ha) to 16600 feddan (=6972 ha) which represents 16.6 % of the total area of the Lake (reduction rate = 33.1 %). The estimated maximum standing crop phytomass in

the Lake as whole was 239040 ton dry matter: 170980 ton represents the above water standing crop, and 68060 ton represents the submerged portion.

The contents of organic and inorganic constituents and the calculated nutritive values of the green and dry parts of the shoots of the common reed indicated that the green parts is good or excellent fodder particularly during the spring season. Fortunately, microelements (i.e. heavy elements) have higher accumulation rate in the dry parts than in the green ones, and most of the estimated macro- and microelements are within the tolerable range in feeds commonly used in rations of sheep, goat and cattle.

The best way to control this plant is the deep ploughing followed by rotary hoaing using amphibian machines. The cutting below the water level is also efficient. However, if we take into account the analysis of Landsat images and the benefits of the common reed, it can be concluded that the infestation degree is not severe. But in some places, the reed infestation may be lead to the fragmentation of the lake into four disconnected basins: one at each of the outermost east and west sides, and two at the middle. Thus it is suggested to remove the reed from the narrow areas (as the case of the western side) and between the islets scattered in the Lake (as in the middle and eastern sides), and to remove also the reed close to the south - eastern shores for at least 100 m inside the lake in order to stop the raising up of lake bed and to prevent its permanently connection with the land.

The ancient plant succession in Burullus Wetland may be happened as follows: before the time the soil at 30 m deep had been deposited, this region was part of the sea. After that, regression of the sea took place and the Nile water began to reach this area; xerophytes, hydrophytes and helophytes appeared and limited lagoons were formed. Nearly 20000 years ago, blocking of the Nile took place, but there was tremendous rainfall, on northern Egypt. Consequently, swamps covered by *Cyperus papyrus* had spreaded allover the area. Cold seasons probably followed, as indicated by the appearance of *Betula* and *Ulnus* pollen in the samples. After that, rainfall had decreased and swamps had limited, this was probably due to more deposition of transported matter by the Nile during erosion stage. Consequently, terrestrial plants began to flourish; and oscillations in the Nile run-off and the richness of the wild plants, with a rise in the sea level, took place. This was, probably, due to changes in solar radiation. The last picture was retreating of swamps and stabilization of land cultivation, as a result of continuous siltation.

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4.9. PLATES OF VASCULAR PLANTS (4.1 – 4.15)

(after Täckholm 1974*, Boulos 1999, 2000 & 2002** and by K.H. Shaltout ***)

Plate 4.1
*Salix tetrasperma***
*Persicaria salicifolia**
*Emex spinosa***
*Mesembryanthemum crystallinum**

Plate 4.2
*Atriplex halimus***
*Portulaca oleracea***
*Atriplex portulacoides***
*Chenopodium album***

Plate 4.3

*Chenopodium ambrosioides***
*Salsola kal**
*Cornulaca monacantha****

*Suaeda pruinosa**

Plate 4.4
*Sarcocorinia fruticosa***
*Amaranthus lividus***
*Adonis dentata***
*Sisymbrium irio***

Plate 4.5
*Alhagi graecorum**
*Zygophyllum album***
*Ricinus communis***

Plate 4.6
*Ludwigia stolonifera**
*Anagallis arvensis***
*Sida alba***
*Tamarix nilotica***

Plate 4.7
*Cynanchum acutum***
*Tamarix aphylla***
*Convolvulus lanatus****
*Ipomoea carnea****

Plate 4.8
*Mentha longifolia**
*Phyla nodiflora***
*Sphaeranthus suaveolens**
*Cistanche phelypaea**

Plate 4.9

*Plantago major***
Cichorium endivia subsp. *pumilum***
*Centauria calcitrapa**

*Artemisia monosperma****

Plate 4.10
*Conyza bonariensis***
*Echinops spinosissimus***
*Filago desertorum***
*Pluchea dioscoridis**

Plate 4.11
*Ifloga spicata***
Senecio glaucus subsp. *coronopifolius****
*Silybum marianum***
*Sonchus oleraceus***

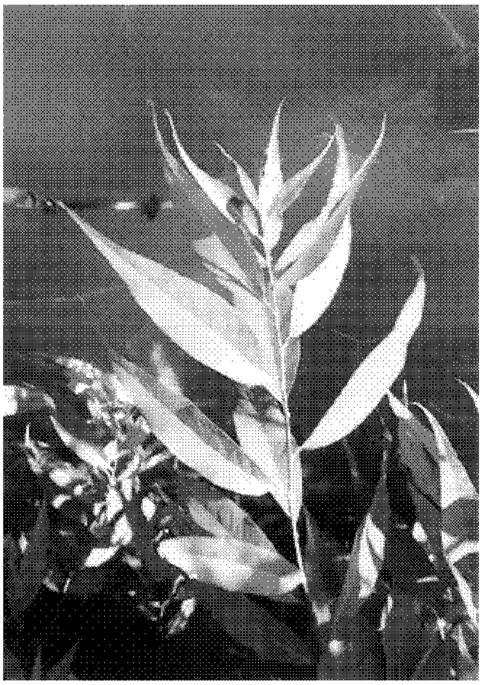
Plate 4.12
*Imperata cylindrica**
*Saccharum spontaneum**
*Paspalum distichum**
*Echinochloa colona**
*Cyperus alopecuroides**

Plate 4.13
*Lemna gibba**
*Typha domingensis**

Plate 4.14
Collection of reeds from the lake***
Air drying of reed stems***
Preparation of mats from reeds***
Collection of the prepared mats***
Burning of reeds in Lake Burullus***
The geese graze the water hyacinth in Berimbal Canal***

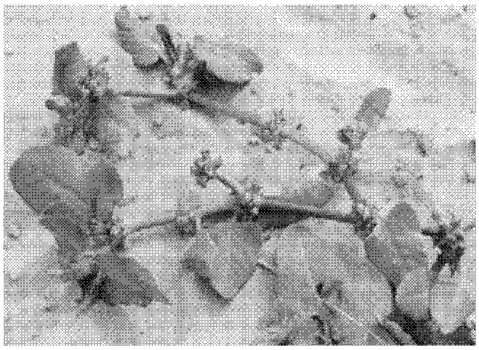
Plate 4.15
A goat grazes the water hyacinth along the lake shore***
A cow graze water hyacinth***
Plant collection for using as fuel***
Plant collection for using as fuel***
Palm plantation in Burullus***

Plate 4.1

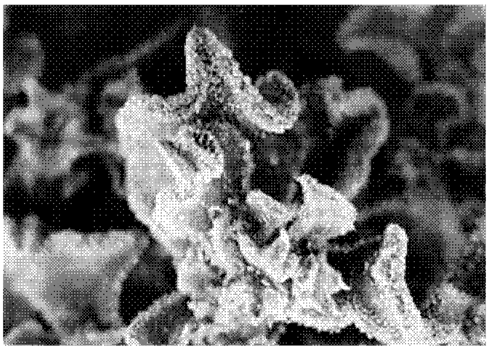


Salix tetrasperma صفصاف أفرنجى

Persicaria salicifolia زلفة



Emex spinosa ضرس العجوز

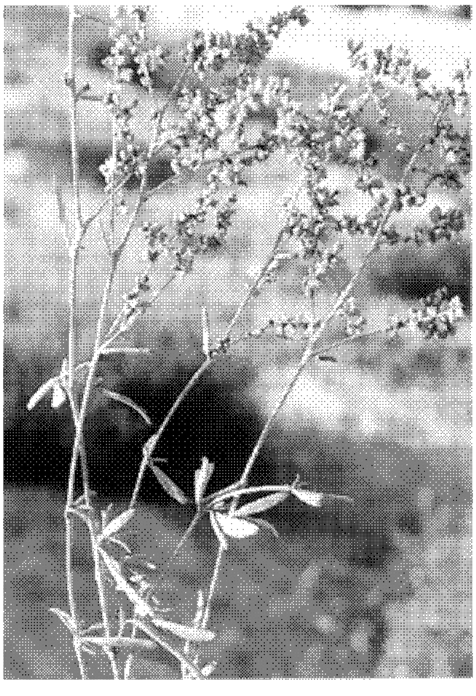


Mesembryanthemum crystallinum غسول

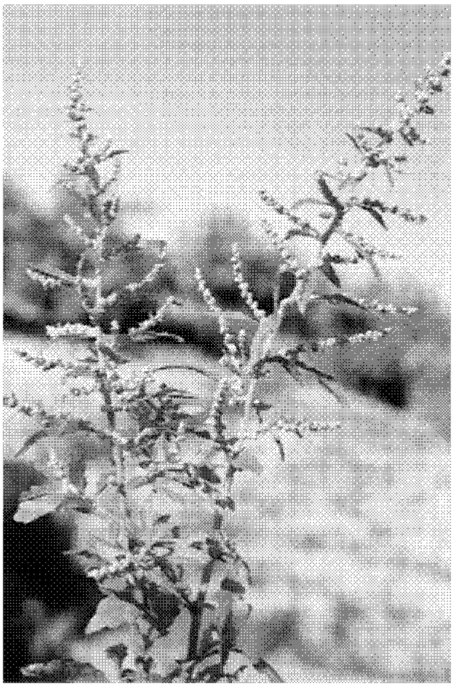
Plate 4.2

Atriplex halimus رجات

Portulaca oleracea رجلة

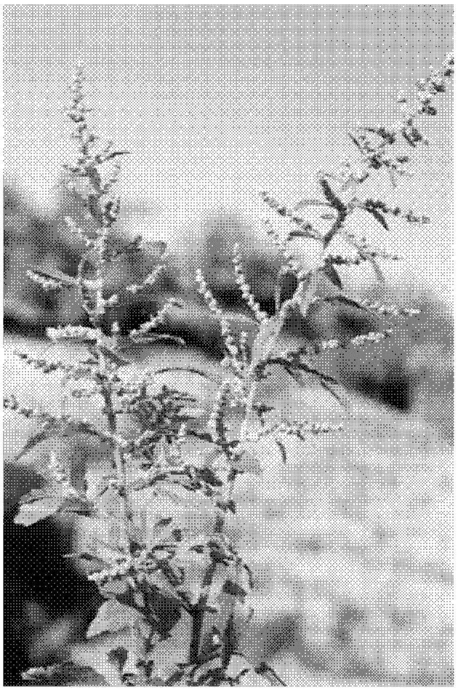


Atriplex portulacoides قطف

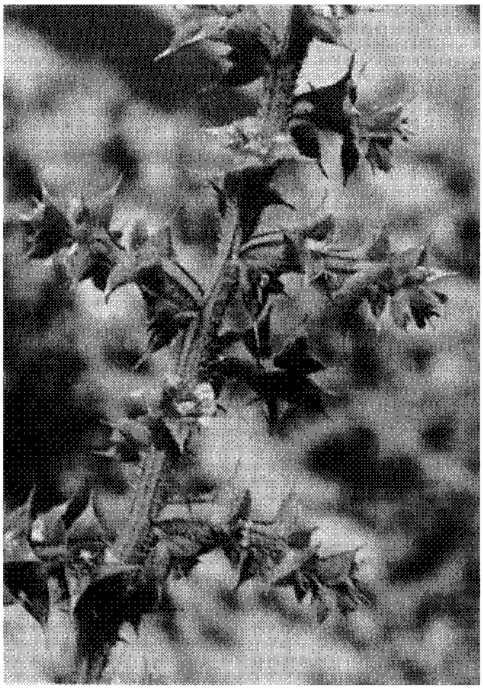


Chenopodium album ركب الجمل

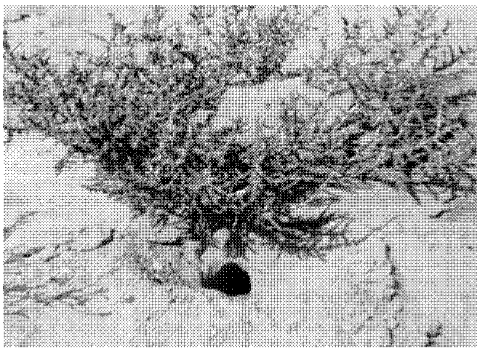
Plate 4.3



Chenopodium ambrosioides زربيح



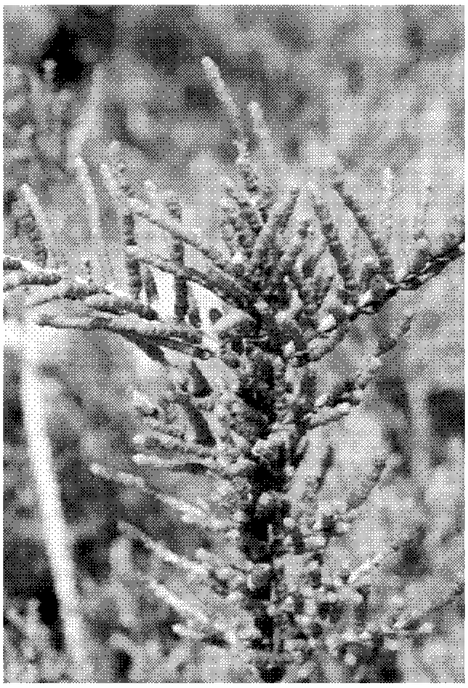
Salsola kali أشنان



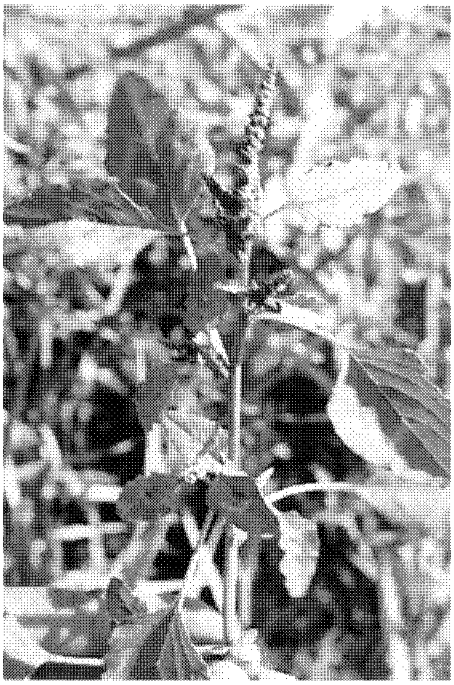
Cornulaca monacantha شوك الديب

Suaeda pruinosa حطب سويدى

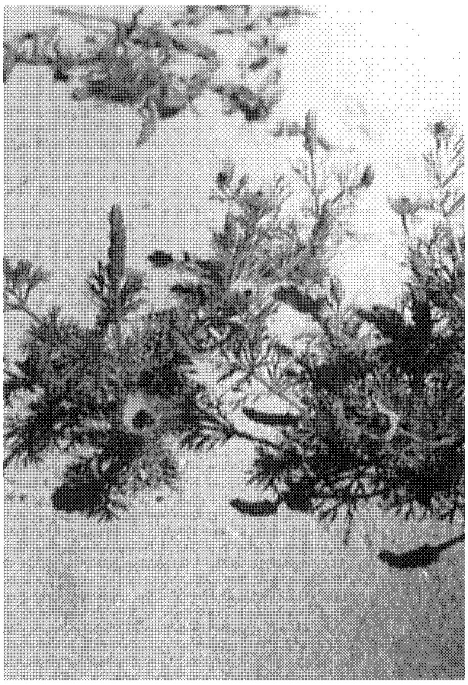
Plate 4.4



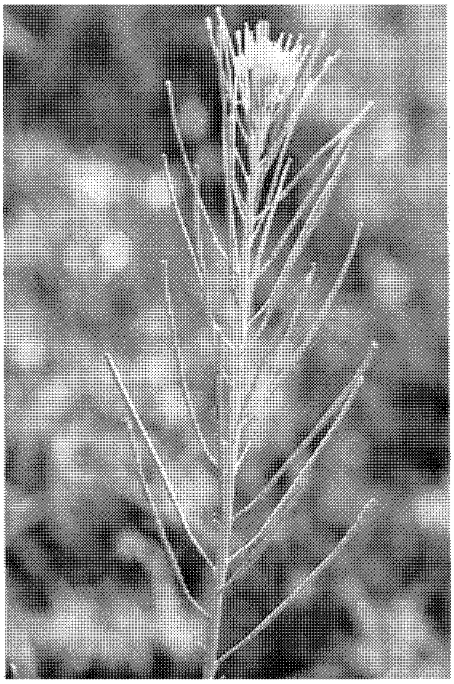
Sarcocorinia fruticosa **أبو ساق**



Amaranthus lividus **أمارنطون**

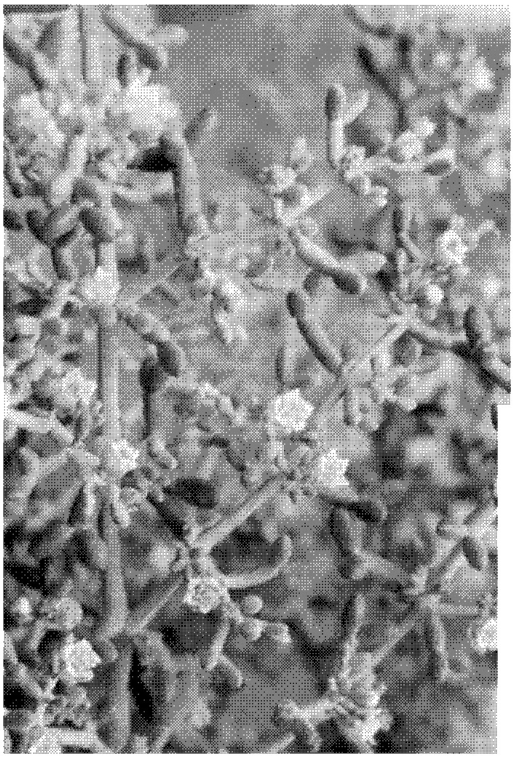


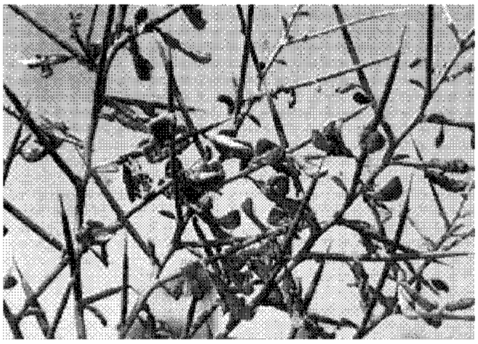
Adonis dentata **ناب الحمل**



Sisymbrium irio **فجل الجمل**

Plate 4.5



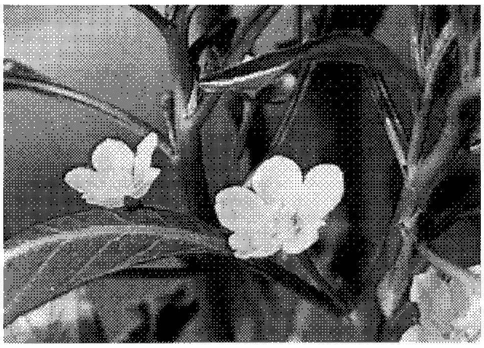


Alhagi graecorum عاقول

Zygophyllum album رطريط أبيض

Ricinus communis خروع

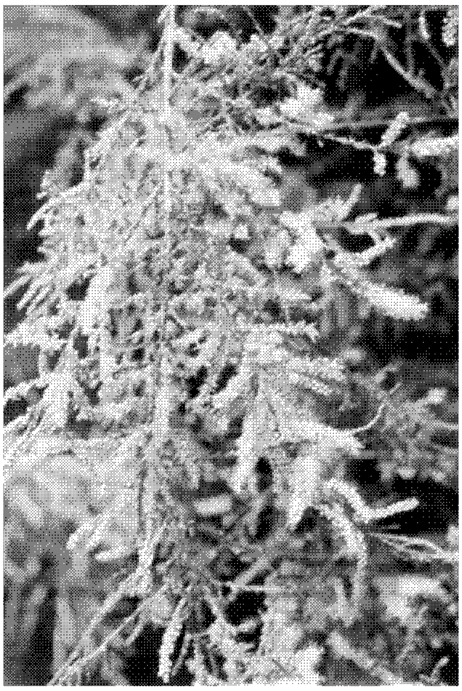
Plate 4.6



Ludwigia stolonifera مداد

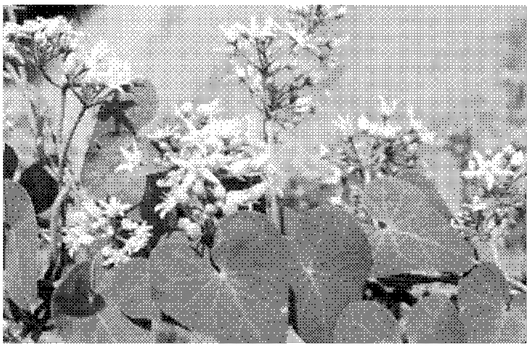
Anagallis arvensis عين الجمل

Sida alba ملوخية ابليس



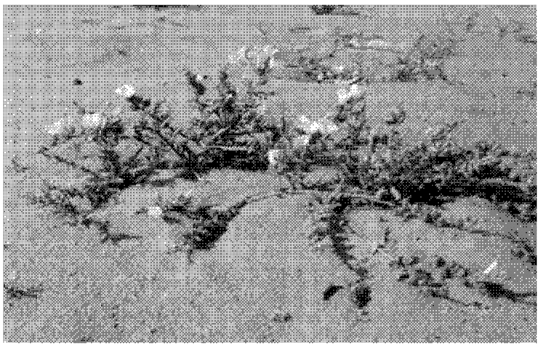
Tamarix nilotica مور

Plate 4.7

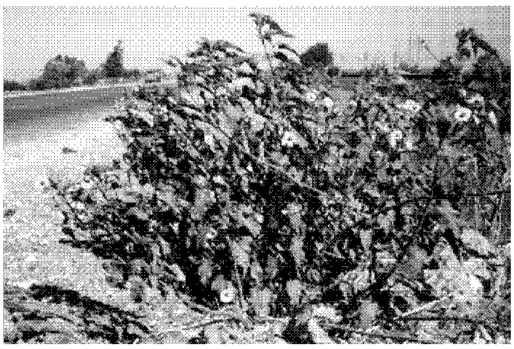


Cynanchum acutum علیق

Tamarix aphylla آتل

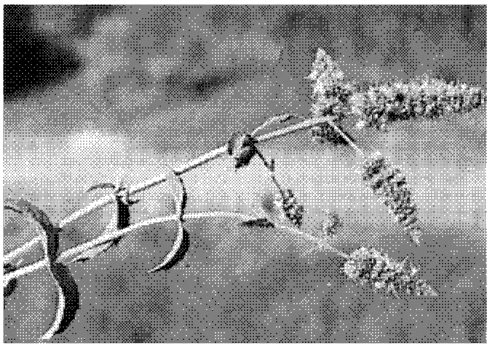


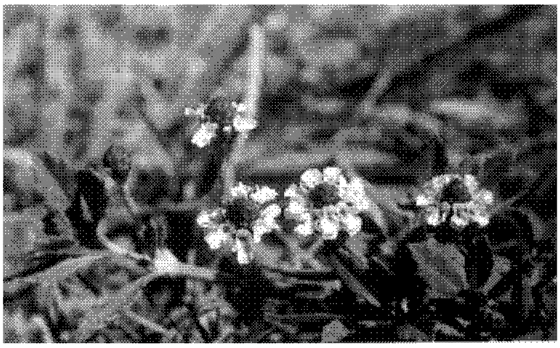
Convolvulus lanatus بياضة



Ipomoea carnea عليق الكبير

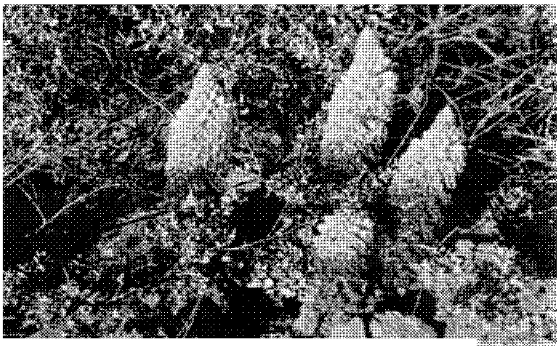
Plate 4.8





Mentha longifolia نعنع

Phyla nodiflora ليبيا

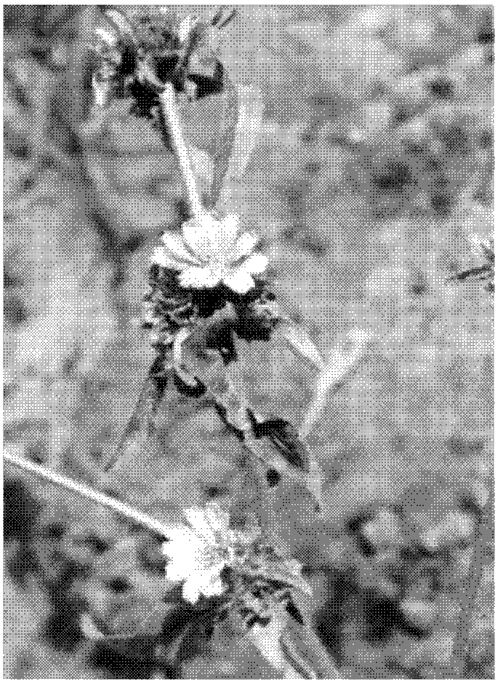


Sphaeranthus suaveolens زر الورد

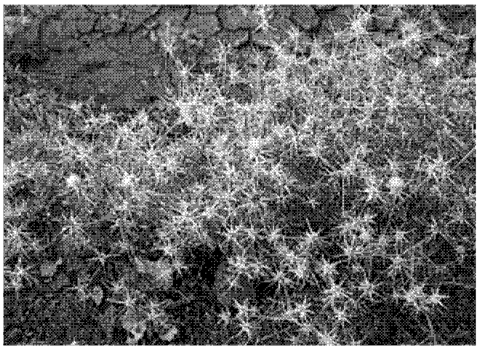
Cistanche phelypaea دآن الجن

Plate 4.9

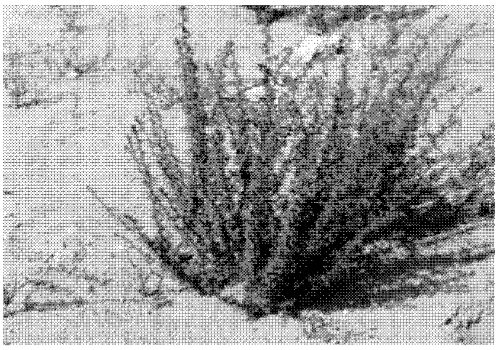
Plantago major لسان الحمل



Cichorium endivia subsp. *pumilum* سريس

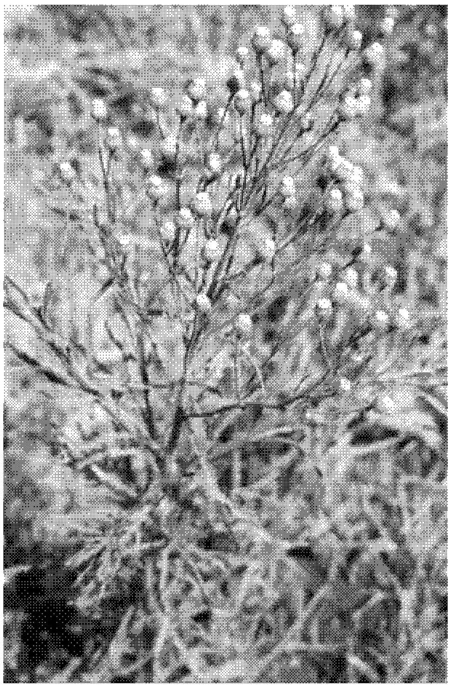


Centauria calcitrapa شوك

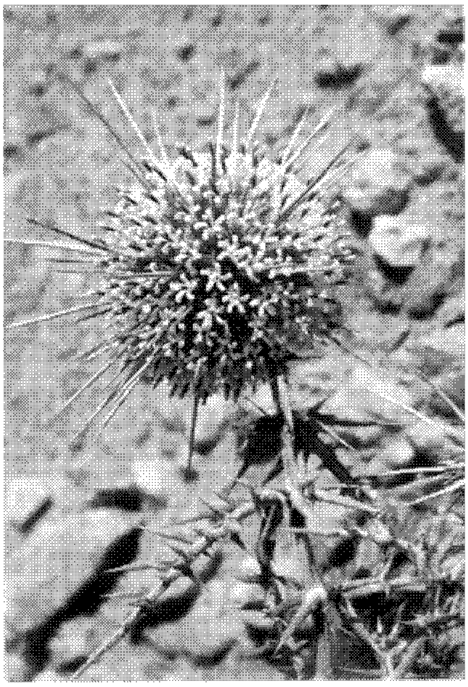


Artemisia monosperma عادر

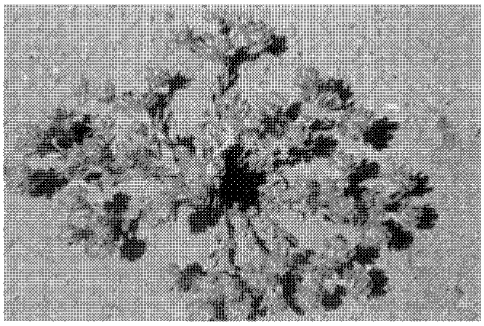
Plate 4.10



Conyza bonariensis حشيشة الجبل



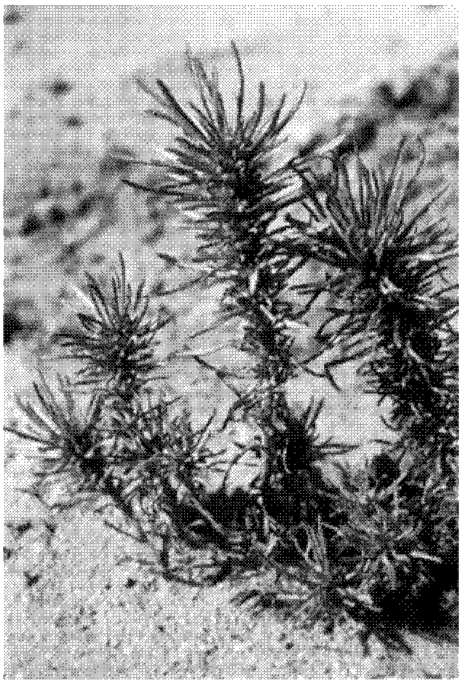
Echinops spinosissimus شوك الجمل



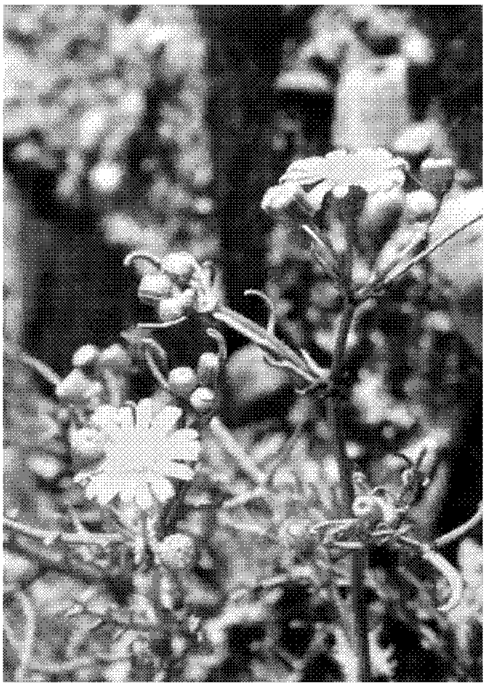
Filago desertorum

Pluchea dioscoridis برنوف

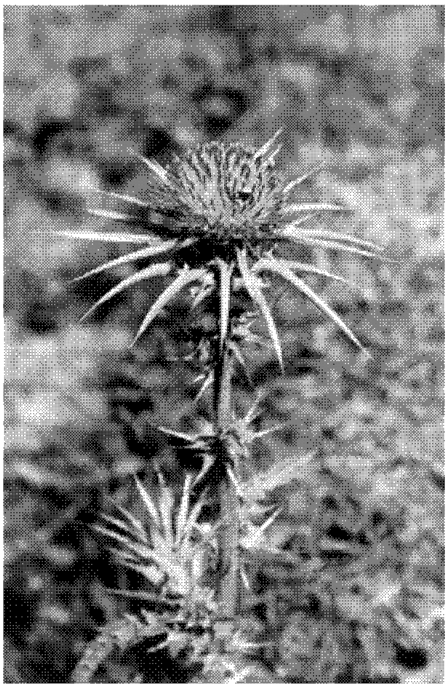
Plate 4.11



Ifloga spicata شجرة المعيز



Senecio glaucus subsp. *coronopifolius* قريص



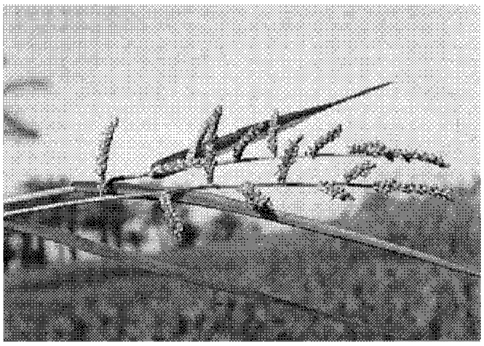
Silybum marianum شوك نصارى

Sonchus oleraceus جعضيض

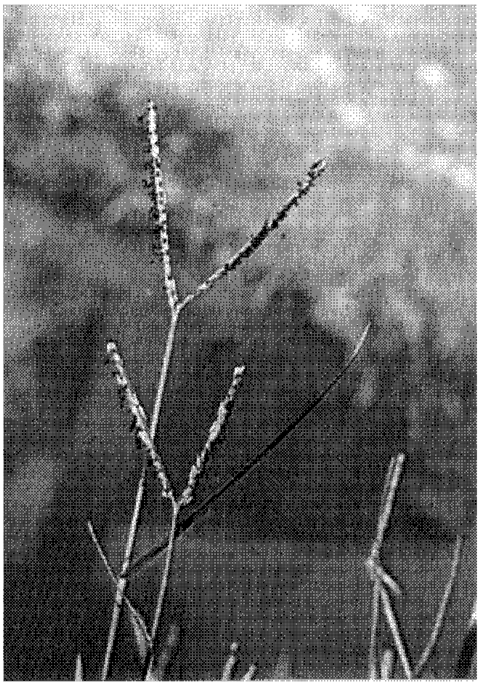
Plate 4.13

Imperata cylindrica حلفا

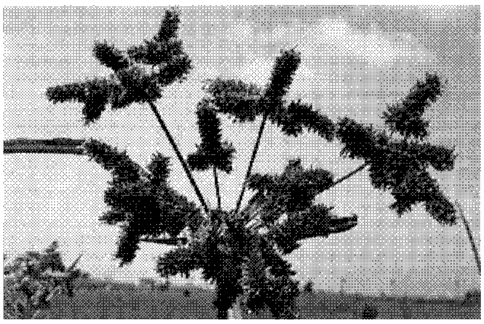
Saccharum spontaneum هيش



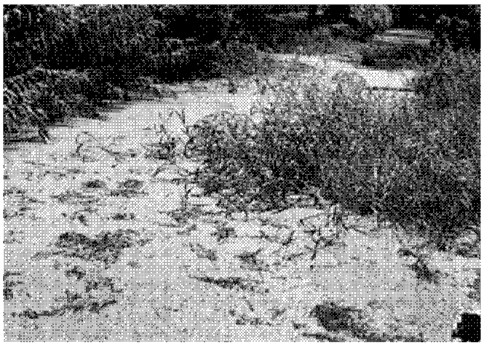
Echinochloa colona أبو ركبة



Paspalum distichum مديد



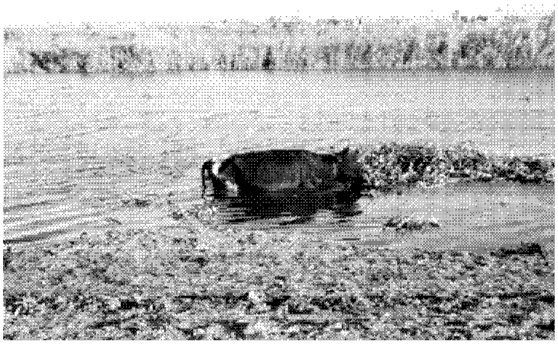
Cyperus alopecuroides سمار حلو



Lemna gibba عدس المية

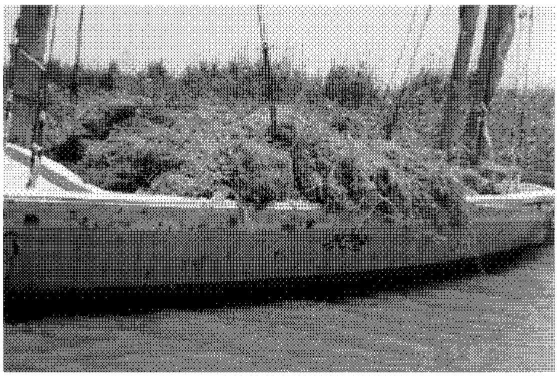
Typha domingensis بردى

Plate 4.15



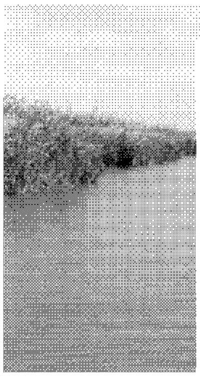
A goat grazes the water hyacinth along the lake shore

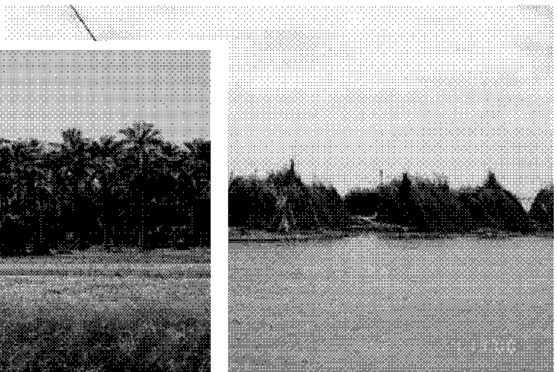
A cow grazes water hyacinth



Plant collection for using as fuel

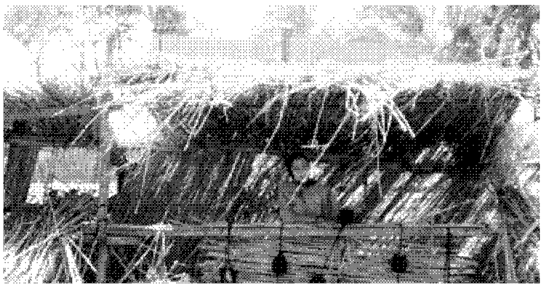
Plant collection for using as fuel





Collection of r **stems**

Palm plantation in Burullus (Baltim)



Chapter 5
Phytoplankton & Epiphytic Algae

5.1. PHYTOPLANKTON

5.1.1. Species Diversity

Fish production in Egypt depends largely on the Egyptian shallow water bodies such as Lake Burullus. The role of phytoplankton as a main source of fish nutrition is well known, and in order to develop the fish economy it is necessary to study well the phytoplankton and the factors affecting its standing crop and productivity. Lake Burullus was investigated limnologically (e.g. Darrag 1974, 1983, Fathi and Abdelzahar, 2003) and phytoplanktonically (e.g. Kobbia 1982, El-Sherif and Aboul Ezz 1988, Samaan *et al.* 1988, El-Sherif 1989, El-Sherif 1993, Zalat and El-Sheekh 1999, Fathi *et al.* 2001, Radwan 2002).

The phytoplankton community of Lake Burullus is considered rich, both in density and species richness, but most of the species are fresh or brackish water forms. From the survey of the literature on phytoplankton assemblages of Lake Burullus, there is a large variation among the researchers in the species composition and density depending on the surveyed station, water depth, sampling season, water quality, environmental condition and water pollution of the lake (Tables 5.1, 5.2, 5.3). For example, Kobbia (1982) recorded 49 species belonging to 6 algal divisions (during one year at three stations and different depths): 14 species of Chlorophyta, 19 of Cyanophyta, 12 of Bacillariophyta, 2 of Cryptophyta, and one species for each of Chrysophyta and Dinophyta. On the other hand, El-Sherif (1993) recorded 113 species distributed among algal divisions as follows: 52 species of Bacillariophyta, 41 of Chlorophyta, 15 of

Cyanophyta, 2 of Euglenophyta (*Phacus setosa* France and *Euglena granulata* (Klebs) Lemm.), 2 of Dinophyta (*Gymodinium* and *Peridinium* spp.) and one Cryptophyta (*Cryptomonadales* sp.).

The study of El-Sherif *et al.* (1989) on the ecology of Bacillariophyta in Lake Burullus indicated the presence of 59 species (Table 5.1), where *Nitzschia* spp. and *Cyclotella meneghiniana* were the dominant diatom species. Zalat and El-Sheekh (1999) recorded 75 diatom species, 48 of them were not recorded in the previous studies. They found that *Cyclotella meneghiniana* was the most dominant species (73 - 89% of the total diatom assemblages). Radwan (2002) studied the spatial and seasonal distribution of phytoplankton standing crop in Lake Burullus in the period from March, 1997 to Febeuary, 1998, which has been indicated a pronounced decrease influx of fresh and saline water in the lake. Eighty three species were recorded belonging to 5 algal groups: 22 species of Chlorophyceae, 14 of Cyanophyceae, 37 of Bacillariophyceae, 8 of Euglenophyceae and 2 species of Dinophyceae. Fathi and Abdelzahar (2003) identified 58 species; out of these, 24 species belong to Chlorophyta, 16 belong to Bacillariophyta, 12 to Cyanophyta, 3 to Euglenophyta, 2 to Dinophyceae and one to Chrysophyta. *Chlorella* sp., *Chlorococcus humicola, Scenedesmus bijuga, Cyclotella meneghiniana, Cylindrospermum* sp. and *Rhodominas ovalis* were observed in a high rank of occurrence. Generally, the phytoplankton crop showed a remarkable increase as compared with the previous records (Fathi *et al.,* 2001) and the study indicated high level of eutrophication in the Lake. Recently, Okbah and Hessien (2005) recorded a total of 170 species, represented mainly by Bacillariophyceae (47.49% of the total standing crop) comprising 68 species, Chlorophyceae (39.44%) 54 species, Cyanophyceae (8.46%) 16 species, Euglenophyceae (3.96%) 15 species, Dinophyceae (0.64%) 6 species and Silicoflagellate (0.001%) one species. The phytoplankton standing crop showed a pronounced increase as compared with previous studies. Phytoplankton standing crop attained the highest counts at the western sector, particularly. From the above historical review, it is evident that the phytoplankton community in general, and that of diatoms in particular, changed from 1982 till 1999 and these changes in number and dominant species should be taken into consideration for further studies in the lake in order to explore the reasons of these changes

The summing up of all the recorded species in one checklist indicates the presence of 280 species distributed as follows: 145 species belonging to Bacillariophyta (51.8 %), 73 species to Chlorophyta (26.0 %), 52 species to Cyanophyta (18.6 %) and 10 species to other divisions (3.6 %) (Fig. 5.1).

Table 5.1. **List of Bacillariophyta (i.e. Diatoms) recorded in Lake Burullus (After Kobbia 1982, El-Sherif *et al.* 1989, Zalat & El-Sheekh 1999, Fathi *et al.* 2001, Radwan 2002).**

Algal species	1982	1989	1999	2001	2002
Division: Bacillariophyta **Class: Bacillariophyceae** **A- Subclass: Centrales**					
Order: Aulocosirales **Family : Aulocosiraceae**					
1. *Aulocoseira ambigua* (Grunow) Simonsen	-	-	+	-	-
2. *Aulocoseira distans* (Ehre.) Simonsen	-	-	+	-	-
3. *Aulocoseira granulata* (Ehre.) Simonsen	-	-	+	+	-
4. *Aulocoseira granulata var. angustissima* Simonsen	-	-	+	-	-
5. *Aulocoseira islandica* Simonsen	-	-	+	-	-
6. *Aulocoseira italica* (Ehre.) Simonsen	-	-	+	-	-
7. *Aulocoseira* sp.	+	+	-	-	-
8. *Aulocoseira varians* Agardh	-	+	-	-	-
Order: Bidulphiales **Family: Bidulphiaceae**					
9. *Bidulphia laevis* Ehrenberg	-	+	-	-	-
10. *Hyalodiscus laevis* Ehrenberg	-	+	-	-	-
11. *Plagiogramma interruptum* (Gregory) Ralfs	-	-	+	-	-
12. *Podosira montagnei* Kützing	-	+	-	-	-
Family: Thalassiosiraceae					
13. *Cyclotella atomus*	-	-	-	+	+
14. *Cyclotella kutzingiana* Thwaites	+	-	+	-	+
15. *Cyclotella Kutzingii* Kutz	-	-	-	-	+
16. *Cyclotella meneghiniana* Kützing	-	+	+	+	+
17. *Cyclotella ocellata*	-	-	-	+	+
18. *Stephanodiscus invisitatus*	-	-	-	+	-
19. *Stephanodiscus minutulus* (Kützing) Grunow	-	-	+	-	-
20. *Thalassiosira rotula* Menu.	-	+	-	-	-
21. *Thalassiosira weisflogii*	-	-	+	+	-
22. *Melosira granulata* (Ehr.) Ralfa	-	-	-	+	+
23. *Melosira varians* Ag	-	-	-	-	+
B- Subclass: Pennales					
Order: Fragilariales **Family: Fragilariaceae**					
24. *Asterionella japonica* Cleve	-	+	-	-	-
25. *Fragilaria brevistriata* Grunow	-	-	+	-	-
26. *Fragilaria capucina*	-	-	-	+	-
27. *Fragilaria* construens (Ehrenberg) Grunow	+	-	-	+	-
28. *Fragilaria pinnata* Ehrenberg	-	-	+	-	-
29. *Synedra longissima* W. Sm.	-	-	-	-	+
30. *Synedra nana* Meister	-	-	+	-	-
31. *Synedra reumpens* Kützing	-	+	-	-	-

Table 5.1. Cont. 1

Algal species	1982	1989	1999	2001	2002
32. *Synedra tabulata* Kutz	-	-	-	-	+
33. *Synedra tabulata* (Agardh) Kützing	-	+	+	-	-
34. *Synedra ulna* (Nitzsch) Ehrenberg	+	+	+	+	+
35. *Tabellaria* flocculosa (Rapenhorst) Kützing	+	-	-	-	-
Family Diatomaceae					
36. *Diatoma vulgaris*	-	-	-	-	+
Order: : Achanthales **Family: Achanthaceae**					
37. *Achnanthes brevipes* Agardh	-	-	+	-	-
38. *Cocconeis placentula* Ehrenberg	-	+	-	-	-
39. *Cocconies sp.*	+	-	-	+	+
40. *Rhoicosphenia curvata* Grunow	-	+	-	-	-
Order: : Naviculales **Family: Naviculaceae**					
41. *Amphiprora paludosa* Smith	-	+	-	-	+
42. *Amphiprora surireeoides* Henedy	-	-	+	-	-
43. *Caloneis bacillium* (Grunow) Cleve	-	-	+	-	-
44. *Calonies silicula* Cleve	-	+	-	-	-
45. *Diploneis bombus* A.S.	-	-	-	-	+
46. *Diploneis didyma* Ehrenberg	-	+	-	-	-
47. *Diploneis elliptica* (Kützing) Cleve	-	-	+	-	-
48. *Gyrosigma acuminatum* Kutz.	-	-	-	-	+
49. *Gyrosigma attenuatum* Kützing	-	-	+	-	-
50. *Gyrosigma kutzingii kutz.*	-	-	-	-	+
51. *Mastogolia braunii* Grunow	-	+	-	-	-
52. *Mastogolia elliptica* (Agardh) Cleve& Schmidt	-	+	-	-	-
53. *Mastogolia smithii* Thwaites	-	+	-	-	-
54. *Navicula atomus* Kützing	+	-	+	-	-
55. *Navicula cincta* (Ehrenberg) Ralfs	-	-	+	-	-
56. *Navicula cocconeiformis* Gregory	-	-	+	-	-
57. *Navicula cryptocephala* Kutz	-	+	+	-	+
58. *Navicula cuspidada* Kutz	-	+	+	-	+
59. *Navicula decussis* Ostrub	-	-	+	-	-
60. *Navicula digitatoradiata* Gregory	-	-	+	-	-
61. *Navicula gastrum* Ehrenberg	-	-	+	-	-
62. *Navicula gracilis* Ehrenberg	-	+	-	-	+
63. *Navicula gregaria* (Ralss) N. Britchard	-	+	-	-	-
64. *Navicula humerosa* Breb.	-	+	-	+	-
65. *Navicula mutica* Kützing	+	-	-	-	-
66. *Navicula pupula* Kützing	-	-	+	-	-
67. *Navicula radiosa* Kützing	-	-	+	-	-
68. *Navicula schizonemoids* H. van Heruck	-	+	-	-	+
69. *Navicula* sp.	-	+	-	-	-

Table 5.1. Cont. 2

Algal species	**1982**	**1989**	**1999**	**2001**	**2002**
70. *Navicula spicula* Cleve	-	-	+	-	-
71. *Navicula viridula* Kützing	-	+	-	-	-
72. *Navicula yarrensis* Grunow	-	+	-	-	+
73. *Pinnularia acrosphaeria* Rabenhorst	-	-	+	-	-
74. *Pinnularia maior* (Kützing) Rabenhorst	-	-	+	-	-
75. *Pinnularia microsauron* var. *brebissonii* Mayer	-	-	+	-	-
76. *Pinnularia* sp.	+	-	-	-	-
77. *Pleurosigma angulatum* Quekett	-	-	+	-	-
78. *Pleurosigma decorum Smith*	-	+	-	-	-
79. *Pleurosigma delicatulum*	-	-	-	-	+
80. *Pleurosigma elongatum* Smith	-	+	-	-	+
81. *Pleurosigma macrum* W.Smith	-	+	-	-	-
82. *Pleurosigma salinarum Grunow*	-	-	+	-	-
83. *Stauroneis anceps* Ehrenberg	-	-	+	-	+
84. *Stauroneis smithii* Grunow	-	-	+	-	-
Family: Gomphonemaceae					
85. *Gomphonema clevei* Fricke	-	-	+	-	-
86. *Gomphonema constrictum* Ehrenberg	-	+	-	-	-
87. *Gomphonema gracilis* Ehrenberg	-	-	+	-	-
88. *Gomphonema interiactum* Kützing	-	+	-	-	-
89. *Gomphonema lanceolatum* Ehrenberg	-	-	+	-	-
90. *Gomphonema olivacum* Kützing	-	+	-	-	-
91. *Gomphonema parvulum* Kützing	-	-	+	-	-
92. *Gomphonema subclavatum* Grunow	-	+	-	-	-
93. *Gomphonema truncatum* Ehrenberg	-	-	+	-	-
Order: Bacillariales **Family: Bacillariophyceae**					
94. *Bacillaria paradoxa* Gemlin	-	+	+	-	+
95. *Bacillaria sp.*	+	-	-	-	-
96. *Nitzschia acuminata* W.Smith	-	+	-	-	-
97. *Nitzschia amphibia* Grunow	-	+	-	-	-
98. *Nitzschia angustata* Grunow	-	-	+	-	-
99. *Nitzschia apiculata* (Gregory) Grunow	-	+	+	-	-
100.*Nitzschia closterium* Smith	-	+	-	-	+
101.*Nitzschia frustulum* Hustedt	-	+	+	+	-
102.*Nitzschia granulata* Grunow	-	-	+	-	-
103.*Nitzschia hungarica*	-	-	-	+	-
104.*Nitzschia levidensis* var. *salinairum* Grunow	-	-	+	-	-
105.*Nitzschia longissima* (Breb.) Ralfs	-	+	-	-	+
106.*Nitzschia microcephala* Grunow	-	+	+	-	+
107.*Nitzschia obtusa* W.Smith	-	+	+	-	+
108.*Nitzschia palea* (Kützing) W.Smith	-	+	+	-	+
109.*Nitzschia panduriformis* Gregory	-	-	+	-	-
110.*Nitzschia perminuta* (Grunow) Peragallo	-	-	+	-	-
111.*Nitzschia punctata* (Smith) Grunow	-	+	-	-	-
112.*Nitzschia reversa* W.Smith	-	+	-	-	-

Table 5.1. Cont. 3

Algal species	1982	1989	1999	2001	2002
113.*Nitzschia scalaris* (Ehrenberg) W.Smith	-	-	+	-	-
114.*Nitzschia sigma* (Kützing) W.Smith	-	+	+	-	+
Order: Surirellales **Family: Surirellaceae**					
115.*Campylodiscus clypeus* Ehrenberg	-	+	-	+	-
116.*Campylodiscus echeneis* Ehrenberg	-	+	+	-+	-
117.*Campylodiscus placentula* Ehrenberg	-	-	+	-	-
118.*Campylodiscus placentula* var. *euglypta* Ehrenberg	-	-	+	-	-
119.*Cymatoplura solea* (Brebisson) W.Smith	-	-	+	-	-
120.*Surirella striatula* Turpin	-	+	-	+	+
Order: Cymbellales **Family: Cymbellaceae**					
121.*Amphor ovalis* Kützing	-	+	+	-	+
122.*Amphora coffeaeformis* (Agardh) Kützing	-	+	-	-	-
123.*Amphora paludosa* Sm.	-	-	-	+	+
124.*Amphora venata* Kützing	-	-	+	+	-
125.*Cymbella affinis* Kirtx	-	+	-	-	-
126.*Cymbella cistula* (Hempr) Kirch.	-	-	-	+	+
127.*Cymbella microcephala* Grunow	+	-	-	-	-
128.*Cymbella minuta* Hilse	-	-	+	-	-
129.*Cymbella silesiaca* Bleisch	-	-	+	-	-
130.*Cymbella* sp.	+	-	-	-	-
131.*Cymbella turgida* Gregory	-	+	+	-	-
Order: Ropalodiales **Family: Ropalodiaceae**					
132.*Epithemia smithii* Carruthers					
133.*Epithemia sorex* Kützing	-	-	+	-	-
134.*Epithemia turgida* Gregory	-	-	+	-	-
135.*Epithemia zebra* (Ehrenberg) Kützing	-	+	+	-	-
136.*Rhopalodia acuminata* Kramer	-	-	+	-	-
137.*Rhopalodia gibba* (Ehrenberg) O. Müller	-	+	+	-	-
138. *Rhopalodia gibba* var. *ventricosa* (Kützing) Grunow	-	-	+	-	-
139.*Rhopalodia gibberula* (Ehrenberg) O. Müller	-	+	-	-	-
140.*Rhopalodia rhopala* (Ehrenberg) Hustedt	-	-	+	-	-
Order: Chaetocerales **Family: Chaetoceroaceae**					
141.*Chaetoceros compressus* Lauder	-	+	-	-	-
Order: Eunotiales **Family: Eunotiaceae**					
142.*Eunotia* sp.	-	-	+		
Total	**12**	**59**	**75**	**32**	**36**

Table 5.2. **List of Chlorophyta recorded in Lake Burullus (After Kobbia 1982, El-Sherif *et al.* 1993; Fathi *et al.* 2001, Radwan 2002).**

Algal species	1982	1993	2001	2002
Division: Chlorophyta Class: Chlorophyceae				
Order: Volvocales Family: Chlamydomonaceae				
1- *Carteria hantzschii* Lagerh.	-	-	+	-
2- *Carteria cordiforme* (Carter) Diesing	-	+	-	-
3- *Chlamydocapsa planctonica* ***Ehren.***	+	-	-	-
4- *Chlamydomonas reinhardtii* Dang	-	+	-	-
Family: Volvocaceae				
5- *Eudorina* sp.	+	-	-	-
6- *Pandorina morum* (Muell.) Bory	-	+	-	-
7- *Phacotus lentcularis* Ehren.	+	-	-	-
Order: Tetrasporales **Family: Palmellaceae**				
8- *Sphaerocystis schroeteri* Chodat	-	+	-	-
Family: Coccomyxaceae		-	-	-
9- *Elakatothrix biplex* **Wille**	+	-	-	-
Family: Ulothrichaceae			-	-
10- *Geminella minor* (Naeg.) Heering	-	+	-	-
Order: Cladophorales Family: Cladophoraceae				
11- *Cladophora* Sp.	+	+	-	-
Order: Oedogoniales Family: Oedogoniacea				
12- *Oedogonium* sp.	-	+	-	-
Order: Chlorococcales Family: Hydrodictyaceae				
13- *Pediastrum boryanum* (Turp.) Meneghini	-	+	+	+
14- *Pediastrum duplex* Meyen	-	+	+	+
15- *Pediastrum simplex* (Meyen) Lemmermann	-	+	+	+
16- *Pediastrum simplex vat. duodenarium* (Bailey)	-	-	-	+
17- *Pediastrum tetras* (Ehrenb.) Ralfs	-	+	+	+
Family; Chlorococcaceae				
18- *Chlorococcum humicula* Nag.	-	-	+	+
Family: Coelastraceae				
19- *Coelastrum cambricum* Archer	-	-	+	-
Family: Botryococcaceae				
20- *Botryococcus braunii* Kuetzing	+	-	-	-
Family: Oocystaceae				
21- *Ankistrodesmus falcatus* var. *acicularis* (A.Braun)	-	+	+	+
22- *Ankistrodesmus falcatus* var. *mirabile* (West&West)	-	+	+	+
23- *Ankistrodesmus falcatus* var. *spirilliformis* G.S.West	-	+	+	-
24- *Ankistrodesmus hantzschii* Lagerh	-	-	+	-
25- *Ankistrodesmus setigerus* (Schrod.) G.S.West	-	+	-	-

Table 5.2. Cont. 1

Algal species	1982	1993	2001	2002
26- *Chlorella* sp.	+	-	-	-
27- *Chlorella vulgaris* Beji	-	-	+	+
28- *Chodatella subsala* Lemm.	-	+	-	-
29- *Dictyosphaerium pulchellum* Wood	-	+	+	-
30- *Francia droescher* (Lemm.) G.M.Smith	-	+	-	-
31- *Kirchneriella lunaris* (Kirch.) Moebius	-	+	-	-
32- *Kirchneriella microscopica*	+	-	-	-
33- *Monoraphidium capricornutum* Nygaard	-	-	+	-
34- *Monoraphidium capriornutum* Nag.	+	-	-	-
35- *Monoraphidium contortum* Komarava	-	-	+	-
36- *Nephrocytium limneticum* (G.M.Smith) G.M.Smith	-	+	+	-
37- *Oocystis borgei* Snow	-	+	+	-
38- *Oocystis* sp.	+	-	-	-
39- *Selenastrum gracile* Reinch	-	+	-	-
40- *Tetraedron minimum* (A.Braun) Hansgirg	-	+	-	-
41- *Tetraedron muticum* (a. Braun) Hansgirg	-	-	+	-
42- *Tetraedron proteiforme* (Turn.) Brunnthaler	-	+	-	-
43- *Tetraedron trigonum* Hansgirg *var gracile* Reinsch	-	-	+	-
44- *Westella botryoides* (W.West) de Widemann	+	-	-	-
Family: Scenedesmaceae				
45- *Actinastrum hantzschii* Lagerheim	-	+	+	+
46- *Cruigenia maritima*	+	-	-	+
47- *Cruigenia quadrata* Morren	-	+	+	+
48- *Cruigenia tetrapedia* (Kirch.) West&West	-	+	-	
49- *Scenedesmu dimorphus (turpin) Kutz.*	-	-	-	+
50- *Scenedesmus acuminatus* (Lagerh.) Chodat	-	+	+	+
51- *Scenedesmus armatus* (Chodat) G.M.Smith	-	+	+	+
52- *Scenedesmus bijugatus* (Turp.) Kuetz.	-	+	+	+
53- *Scenedesmus bijugatus* Var. *alternans* Hansg.	-	+	+	+
54- *Scenedesmus diagonals* S.Fang	-	+	+	-
55- *Scenedesmus incrassatulus* Chodat	-	-	+	-
56- *Scenedesmus opliensis* Rich	-	+	+	-
57- *Scenedesmus quaricauda* (Turp.) Breb	-	+	+	-
58- *Scenedesmus spinosus*	+	-	+	-
59- *Scenedsmus dimorphus* (turpin) Kuz	-	-	-	+
60- *Tetrastrum stturogeniaeforme* (Schroeder) lemm.	+	-	-	-
61- *Tetrastrum triagulare*	+	-	-	-
Order: Zygnematales **Family: Zygnemataceae**				
62- *Spirogyra hassalli* (Dnner) Petit	-	+	-	-
Order: Desmidiales **Family: Desmidiaceae**				
63- *Closterium parvulum* var. *angustum* W.& G.S.West	-	+	-	-
64- *Cosmarium elfungii* Racib	-	+		+

Table 5.2 Con.2

Algal species	1982	1993	2001	2003
65- *Cosmarium* galeatum *W.& G.S.West*	-	+	+	-
66- *Cosmarium phaseolus*	-	-	+	-
67- *Cosmarium subcrenatum* Hanzach	-	+	-	-
68- *Cosmarium sublateraundulatum W.& G.S.West*	-	+	-	-
69- *Cosmarium sublumidum* Nordst	-	-	-	+
70- *Cosmarium subtunidum* Nordst	-	+	+	
71- *Staurastrum paradoxum* Menegh	-	-	+	+
72- *Staurastrum tetracerum* Ralfs.	-	-	+	+
Family: Chlorococcatceae				
73- *Golenkinia radiata*	-	+	-	-
Total	**14**	**41**	**35**	**22**

Table 5.3. **List of Cyanophyta (blue-green algae) recorded in Lake Burullus (After Kobbia 1982, El-Sherif *et al.* 1993, Fathi *et al.* 2001, Radwan 2002).**

Algal species	**1982**	**1993**	**2001**	**2002**
Division: Cyanophyta **Class: Myxophyceae**				
Order: Chrococcales **Family: Chrococcaceae**				
1- *Aphanocapsa pulchra* (Keutz.) Rabenhorst	-	+	-	-
2- *Aphanotheca* sp.	+	-	-	-
3- *Chroococcus dispersus* (Keissl.) Lemmermann	-	+	-	+
4- *Chroococcus limneticus* Lemmermann	+	-	-	+
5- *Chroococcus tenuis* A.Braun	-	+	-	-
6- *Chroococcus turgidus* (Kütz.) Naegeli	+	+	+	+
7- *Coelosphaerium confermis* Naegeli	-	+	-	-
8- *Dactylococcopsis irrigularis* G.M.Smith	-	+	-	-
9- *Gleocapsa rupestris* Kutz.	-	-	-	+
10- *Gleocapsa* sp.	+	-	-	-
11- *Merismopedia elegans* Braum	-	-	+	-
12- *Merismopedia glauca* (Ehrenb) Nagelei	-	-	+	-
13- *Merismopedia minima* Beck	-	+	-	-
14- *Merismopedia punctata* Meyen	-	+	-	+
15- *Merismopedia tenuissima* Lemmermann	+	-	-	+
16- *Microcystis aeruginosa Kutz*	-	-	+	-
17- *Microcystis aeruginosa* Kützing	+	+	-	-
18- *Microcystis flos-aquse* (Wittr) Kirschn	-	-	+	-
19- *Microcystis incerta* Lemm.	-	-	-	+
Order: Nostocales **Family: Nostocaceae**				
20- *Anabaena* sp.	-	+	-	-
21- *Anabaenopsis circularia* (G.S.West) Wol&Miller	-	+	+	+
22- *Aphanizomenon* sp.	+	-	-	-
23- *Aulosira laxa* Kirchner	+	-	+	-

Table 5.3 Cont.1

Algal species	1982	1993	2001	2002
24- *Cylindrospermium* sp.	+	+	+	-
25- *Nostoc ellipsosporum* (Desmaz.) Rabenohorst	+	-	-	-
26- *Nostoc microscopicum* Carmichael	+	-	-	-
27- *Nostoc verrucosum* Vaucher	+	-	-	-
Family: Scytonemaceae				
28- *Plectonema* sp.	+	-	-	-
Family: Rivulariaceae				
29- *Gleotrichia* sp.	+	+	-	-
30- *Rivularia* sp.	+	+	-	-
Order: Oscillatoriales **Family: Oscillatoriaceae**				
31- *Anabaena elenkinii*	-	-	+	-
32- *Anabaenobisis circularis* Wol & Miller	-	-	+	+
33- *Anabaenobsis tanganyikae* Miller	+	-	-	-
34- *Isocystis* sp.	+	-	-	-
35- *Lyngbya contorta* Lemmermann	-	-	+	-
36- *Lyngbya limnetica* Lemmermann	-	+	-	-
37- *Lyngbya major* Meneghini	+	+	-	-
38- *Lyngbya* sp.	+	-	-	-
39- *Oscillatoria agardhii* Comont	+	-	-	-
40- *Oscillatoria brevis*	-	-	-	-
41- *Oscillatoria chalybea* Mertens	-	-	+	-
42- *Oscillatoria formosa* Bory	+	-	+	-
43- *Oscillatoria lacustris* (Kleb) Geit	-	+	+	+
44- *Oscillatoria limnetica* Lemmermann	+	+	+	+
45- *Oscillatoria princeps* Vaucher	-	-	-	+
46- *Oscillatoria princeps* Vaucher	-	+	+	-
47- *Oscillatoria simplissima*	-	-	+	-
48- *Oscillatoria tenuis* var.*natans* Gomont	-	-	+	-
49- *Phormidium limosum*	+	-	-	-
50- *Scytonema sp.*	-	-	+	-
51- *Spirulina* sp.	+	-	-	-
Total	**24**	**19**	**19**	**12**

Table 5.4. **List of Euglenophyta and Dinophyta recorded in Lake Burullus (After El-Sherif *et al.* 1993, Fathi *et al.* 2001, Radwan 2002).**

Algal species	1993	2001	2002
Division: Euglenophyta **Class: Euglenophyceae**			
Order: Euglenales **Family: Euglenaceae**			
1- *Euglena acus* Ehrenberg	-	+	+
2- *Euglena* gracilis Klebs	-	+	+
3- *Euglena granualta* Lemm	-	-	+

Table 5.4. Cont. 1

Algal species	1993	2001	2002
4- *Euglena promxia* Dangeard	-	+	-
5- *Phacus macrostigma* Pachmann	-	+	-
6- *Phacus pleuronectus*	-	+	+
7- *Phacus setosa*	-	-	+
Total	**-**	**3**	**2**
Division: Dinophyta **Class: Dinophyceae**			
Order: Gymnodiniales **Family: Gymnodiniaceae**			
1- *Gmnodinium pusillum*	-	+	-
Order: Peridiniales **Family: Peridiniaceae**			
2- *Peridinium bipes Stein*	-	+	+
3- *Peridinium borgei Lemm*	-	+	+
Total	-	2	2

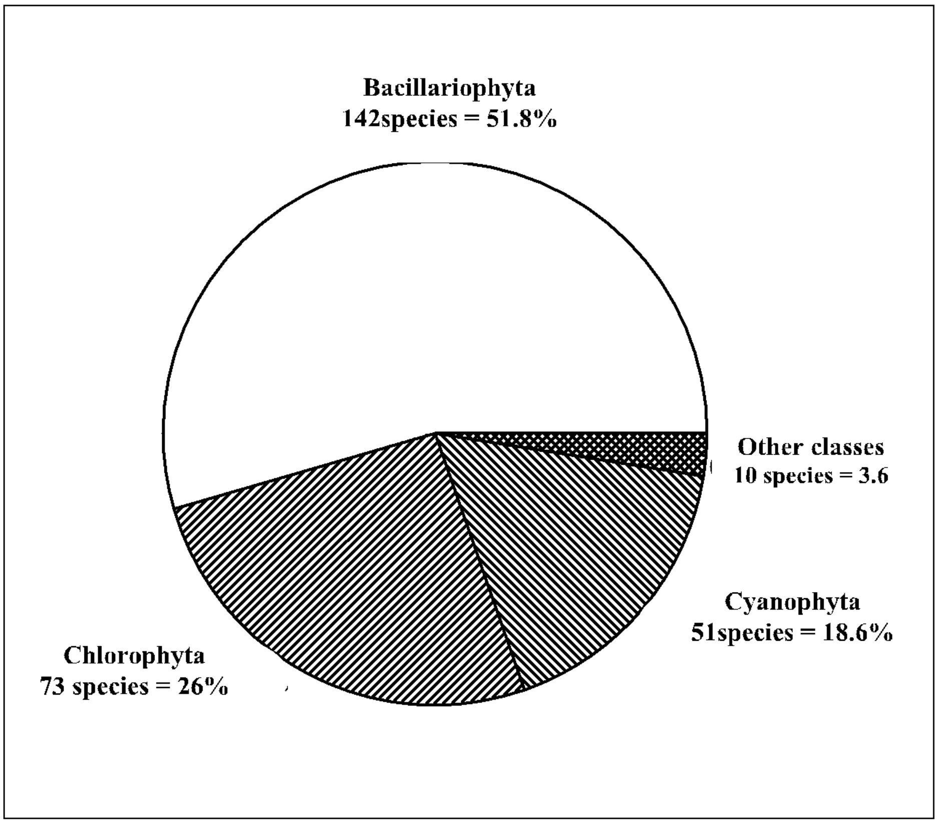


Fig. 5.1. **Contribution of algal divisions to the phytoplankton of Lake Burullus.**

5.1.2. DENSITY AND BIOMASS

El-Sherif (1989) indicated that Bacillariophyta represented the major bulk of the phytoplankton and formed 69.0% of its total biomass, although it ranked numerically as the second important group with 31.1% of the total phytoplankton counts. Chlorophyta was numerically the dominant group as it formed about 58.9% of the total phytoplankton counts, yet it contributed only 16.2% of the total phytoplankton biomass. Similarly the biomass of Cyanophyta was comparable to that of Chlorophyta and it constituted about 14.8% of the total phytoplankton biomass, but it contributed 8.8 % of the total phytoplankton counts. The highest phytoplankton biomass was recorded in the western sector of the lake, as a result of the increased values of diatoms, while the lowest biomass was in the eastern sector (Table 5.4). Okbah and Hessien (2005) recorded a total of 170 species, represented mainly by Bacillariophyceae (47.49% of the total standing crop)

Table 5.5. **Average biomass (mg l^{-1}) and their frequency (%) of the different algal groups in Lake Burullus (after El-Sherif 1989).**

Phytoplankton	Sector			Average	%
	East	Middle	West		
Bacillariophyta	1.273	1.142	2.440	1.618	69.0
Chlorophyta	0.125	0.512	0.505	0.381	16.2
Cyanophyta	0.129	0.387	0.526	0.347	14.8
Total	1.527	2.041	3.471	2.346	100

The monthly fluctuations of the total phytoplankton biomass, as estimated by El-Sherif (1989), indicated that the eastern and middle sectors of the lake showed maximum biomass in early autumn (September). Relatively high values were also recorded during winter (February) in the eastern sector and spring (March) in the Middle sector. The highest abundance peak in the western sector was recorded during summer (June), beside smaller ones in September and December. Most of these peaks were attributed to diatoms (Fig. 5.2). The following is a brief description of the distribution of different algal divisions recorded in the Lake Burullus (after El-Sherif 1989):

5.1.2.1. Bacillariophyta

Diatoms contributed about 69 % of the total weight of phytoplankton (average 1.618 mg l^{-1}). The western sector had the highest diatoms biomass, due to the dominance of *Nitzschia palea, Nitzschia reversa, Cyclotella meneghiniana, Melosira varians, Pleurosigma* sp. and *Synedra ulna*. The other two sectors had more or less comparable biomass of diatom, but showing different frequencies. The main diatoms comprised *Cyclotella meneghiniana* and *Synedra ulna* (Fig. 5.3).

5.1.2.2. Chlorophyta

Members of Chlorophyta contributed about 16.2% of the total weight of phytoplankton (average 0.381 mg l^{-1}). The highest biomass appeared in the middle and western sectors, showing the same dominant species (*Pediastrum simplex, Pediastrum boryanum, Scenedesmus quadricauda, Scenedesmus bijugatus, Oocystis borgei, Geminella minor* and *Dictyospherium pulchellum*), but with different frequencies. The eastern sector had a low green algal biomass, where *Oocystis borgei, Geminella minor* and *Dictyospherium pulchellum* formed the main bulk of chlorophytes

5.1.2.3. Cyanophyta

The blue green algae, as a whole constituted about 14.8% of the total weight of phytoplankton (average 0.347 mg l^{-1}). The western sector harbored the highest value of 0.526 mg l^{-1} due to the dominance of *Microcystis aeruginosa, Lyngbya limnetica, Anabaena* sp. and *Oscillatoria limnetica*. Their total biomass decreased gradually towards the eastern sector but showing similar algal composition.

The study of El-Sherif (1993) indicated that the phytoplankton standing crop had a remarkable decline to about 1.04 x 10^6 units l^{-1} and it represented about 1/3 of the records obtained during the period 1978-1979 (see El-Sherif 1989). The phytoplankton was represented mainly by Bacillariophyta (49.1% of the total number) and Chlorophyta (31.6%), while Cyanophyta (1.7%). Euglenophyta (2.6%), Dinophyta (2.2%) and Cryptophyta (12.7%) were infrequently observed. The increased counts of Cryptophyta was attributed to a bloom of *Cryptomonadales* sp., which was confined to the polluted area in front of Baltim city during May; this was met with lowest species diversity in the lake. The highest phytoplankton counts were recorded in spring and summer at Baltim city and were dominated by the diatoms *Nitzschia* spp. and *Cyclotella meneghiniana*, the green algae *Scenedesmus, Ankistrodesmus* and *Tetraedron* spp., beside the cryptophycean alga *Cryptomonadales* sp. Generally, the lake is regarded as unpolluted habitat except at Baltim station which is characterized by the highest phytoplankton diversity.

In general, Lake Burullus tends to mesotrophy as regards to phytoplankton production. This is attributed to the decreased amount of the drainage water flowing into the lake, and the increased density of the submerged hydrophytes, particularly *Potamogeton pectinatus*. Thus the heavy growth of this hydrophyte should be controlled to increase the phytoplankton production (El-Sherif 1993).

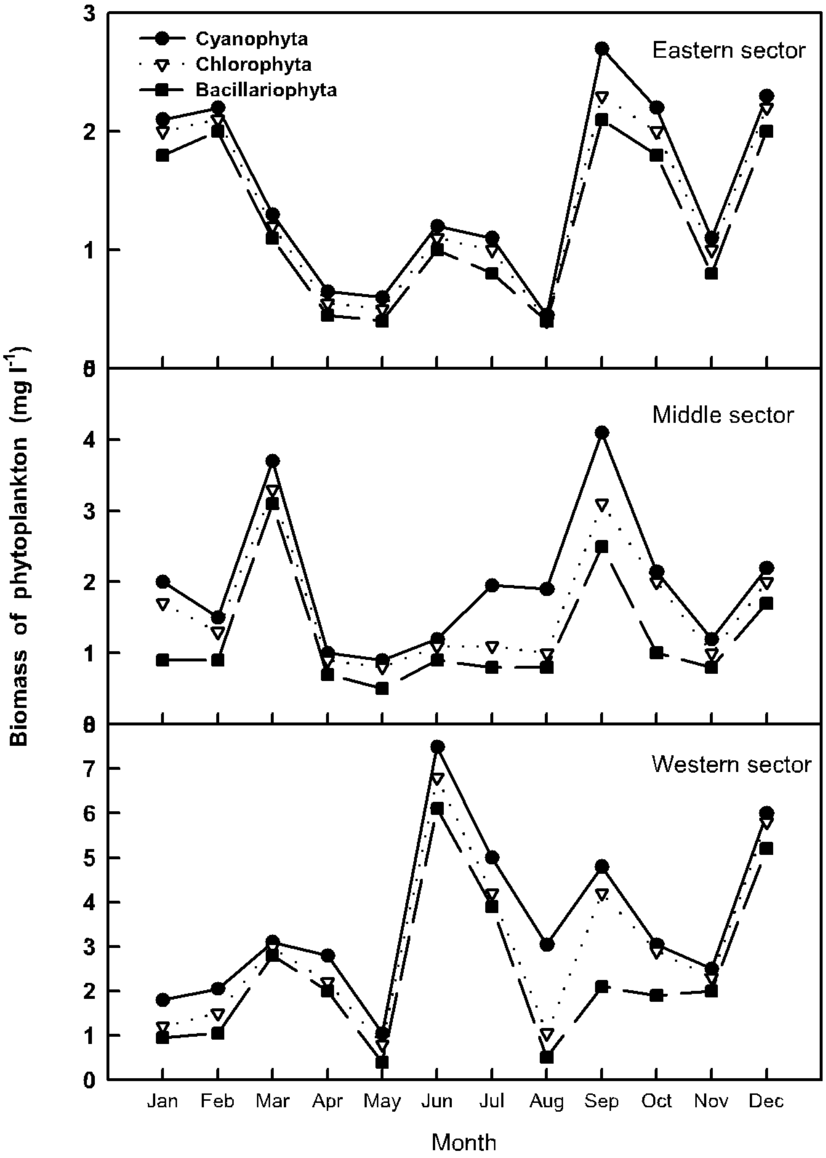


Fig. 5.2. **Seasonal variation in the phytoplankton biomass (mg l^{-1}) recorded in the three sectors of Lake Burullus (El-Sherif 1989).**

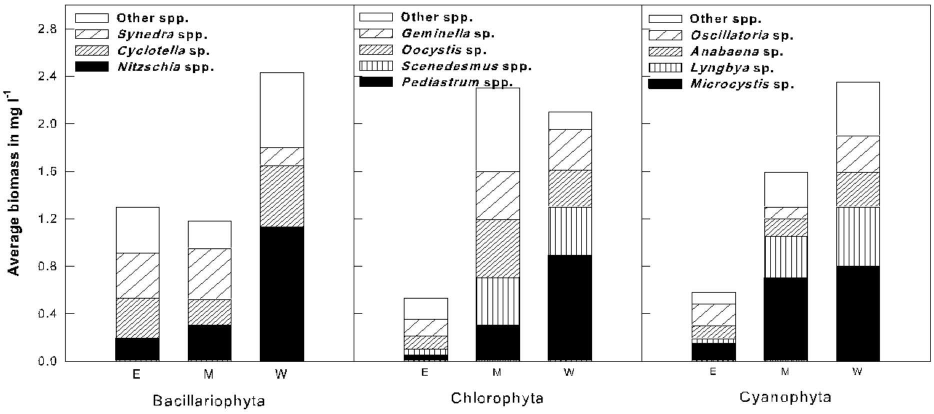


Fig. 5.3. **Average blooms of the different groups of phytoplankton (mg l^{-1}) recorded in the three sectors of Lake Burullus. E: eastern, M: middle and W: western (El-Sherif 1989).**

5.2. EPIPHYTIC ALGAE

Samaan *et al.* (1988) emphasized the importance of epiphytic flora in the Egyptian Delta lakes as they contribute in assessing the biological productivity of these lakes. Epiphytes also constitute important food items for the genus *Tilapia* which represents the most dominant fish inhabiting these lakes (Al-Kholy and Abdel-Malek 1972, El-Sarraf 1976). The lakes in north Nile Delta are shallow and usually sustain extensive areas covered with dense growth of hydrophytes which in turn serve as good support for epiphytes. The hydrophytes in Lake Burullus are represented mainly by *Potamogeton pectinatus* which constituted about 85% of the biomass of submerged plants in the lake (El-Sherif 1983, Shaltout & Al-Sodany 2000). Its distribution was confined to the southern margins beside the outlets of the land drains as well as in the eastern sector. Other submerged plants of minor importance are *Potamogeton crispus, Ceratophyllum demersum* and *Najas armata*.

The study of Samaan *et al.* (1988) on the epiphytes growing on *Potamogeton pectinatus* in Lake Burullus indicated that this submerged hydrophyte supports a rich epiphytic algae, most of them are limnetic forms and can survive in both planktonic and attached conditions. Altogether about 45 species were recorded which included 27 species of Bacillariophyta, 15 of Chlorophyta, 12 of Cyanophyta and one species of Rhodophyta.

5.2.1. Bacillariophyta

Diatoms represented the main group of epiphytic algae on *Potamogeton pectinatus*. The more dominant species were *Cocconeis placentula, Mastogloia elliptica, Mastogloia smithii, Rhopalodia gibba, Rhopalodia gibberula* and

Synedra ulna. On the other hand, *Nitzschia frustulum, Nitzschia microcephala, Nitzschia sigma* and *Epithemia sorex* were less frequent. The other species persisted as rare species. All these diatoms were also recorded in the plankton of the lake (El-Sherif 1983, 1989, 1993).

Cocconies placentula was the most dominant species which appeared all the year round with a maximum frequency in the winter and early spring. It grows firmly attached to the substratum by a gelatinous pad which resists strong water currents. This species is cosmopolitan, oligohalobus- halophilous form (Salah 1960). In addition, *Mastogolia smithii* and *Mastogolia elliptica* were frequently met with all the year round but attaining high peaks on the host plant in May. *Mastogolia smithii* is regarded as indifferent form (Peterson 1943), while *Mastogolia elliptica* is considered as a mesohalobous species.

Rhopalodia gibba appeared as a dominant epiphyte in April and June, while it persisted as a frequent or rare diatom in the other months. *Rhopalodia gibberula* was also dominant in June, otherwise it was rarely observed throughout the rest of the year. The two species were rarely recorded in the plankton. *Rhopalodia gibba* is regarded as oligohalobous halophilous diatom, while *Rhopalodia gibberula* is an indifferent form (Salah 1960). *Synedra ulna* was more frequent on the host plant in late autumn and early winter, but it appeared also frequently in the plankton. This species is regarded as an indifferent form (Peterson 1943).

The frequent species of the genus *Nitzschia* comprised *Nitzschia frustulum, Nitzschia microcephala* and *Nitzschia sigma*. The first one was more frequent in May, September and October, the second in November and the third during June and July. The three species were also frequently observed in the plankton. *Nitzschia frustulum* and *Nitzschia microcephala* are regarded as oligohalobous halophilous diatoms, while *Nitzschia sigma* is considered as mesohalobous (Salah 1960). *Epithemia sorex* appeared also frequently on *Potamogeton* during February, June, July and November; while it remained rare in the other months. This species is regarded as an oligohalobous halophilous diatom.

Other daitoms that persisted as rare epiphytes throughout most of the year were *Synedra tabulata, Rhoicosphenia clirvata, Nitzschia palea, Nitzschia apiculata, Epithemia zebra, Amphora coffeoformis, Amphora ovalis, Cymbella affinis, Gomphonema constrictum, Gomphonema subculvatum, Gomphonema gracile, Mastogloia braunii, Pleurosigma elongatum, Navicula cryptocephela, Navicula schizonemoides, Camplyodiscus clypeus* and *Diploneis didyma*. Most of them are oligohalobous halopilous species except *Synedra tabulata, Nitzschia apiculata, Amphora coffeoformis* and, *Mastogloia braunii* which are mesohalobous species (Samman *et al.* 1988).

5.2.2. Chlorophyta

The epiphytic green algae in the lake were represented by the filamentous genera *Oedogonium*, *Spirogyra* and *Cladophora*, as well as two cellular species of the genera *Closterium* and *Cosmarium*. *Oedogonium* appeared frequently in summer and autumn, and remained rare in the other seasons. The other chlorophytes persisted as rare or very rare epiphytes throughout most of the year except *Closterium* sp. which was restricted to the winter.

5.2.3. Cyanophyta

The epiphytic cyanophytes belonged mostly to the order Oscillatoriales as represented by the genera *Oscillatoria* and *Lyngbya,* and order Nostocales as represented by genera *Anabaena, Anabaenopsis, Gloeotrichia* and *Rivularia.* 5 species of *Oscillatoria* were recorded on *Potamogeton pectinatus*, (*O. brevis, O. tenius, O. simplissima, O. chalybea* and *O. limnetica*). The latter species dominated the other cyanophytes particularly in summer (June). *Lyngbya limnetica* and *Lyngbya major* appeared as frequent epiphytes in spring, but remained rare in the other seasons. The other species appeared as rare or very rare epiphytes during the whole year except *Anabaenopsis tanganyikae* which showed a peak in June.

5.2.4. Rhodophyta

Compsopogon sp. was the only red alga recorded as epiphyte on *Potamogeton pectinatus*. It was frequent in July, otherwise it persisted as a rare form during most of the year and disappeared in winter (Samman *et al.* 1988). This species is a marine alga, which may have invaded the lake through the sea outlet and attached on *Potamogeton pectinatus*.

In general, the maximum frequency of the total epiphytes occurred in winter mainly due to diatoms, and in summer where it consisted chiefly of diatoms and blue green algae. Another small peak occurred in autumn and also was dominated by diatoms and cyanophytes. These peaks were associated with a minimum growth of *Potamogeton*, and consequently reflect an inverse relationship between the growth rates of both two forms of plant life.

5.3. COMPARISON WITH OTHER NORTH AFRICAN LAKES

In a recent study on the phytoplankton communities of nine North African lakes that were investigated within the framework of CASSARINA Project (3 lakes in each of Egypt, Tunisia and Morocco), Fathi *et al.* (2001) indicated that the three Egyptian lakes in Nile Delta (Manzalla, Burullus and Edku), which are alkaline sites with salinities less than 2 gm l^{-1}, are composed of Cosmopolitan algal species and have larger density and more species diversity than the other lakes. Lake Burullus comes in the first regarding the density and diversity (43 species), however this figure of species richness as determined by Fathi *et al.* (2001) underestimates the algal flora of this lake (some 226 species, as indicated

in the present treatise). The relatively high density and species diversity of the Egyptian Nile Delta lakes are despite enrichment problems and substantial land reclamation occurring in the recent decades.

Fathi *et al.* (2001) concluded that, although phytoplankton plays a significant food-web role in all the productive CASSARINA lakes, they are in the Delta lakes a major ecosystem component that contributes to important fisheries status. Further disturbance and pollution of these sites could therefore begin to seriously degrade the quality of phytoplankton community by encouraging greater blue-green abundances with consequent increased threats to water quality. Only by curbing current pollution levels and preventing further losses of open water areas can these lakes continue to function as diverse and usefully productive ecosystems. The threat of climate change (e.g. Jeftic *et al.* 1992) and human usage demands on these important wetlands requires urgent water management activities.

5.4. SUMMARY

The phytoplankton community of Lake Burullus is considered rich, both in density and species richness, but most of the species are fresh or brackish water forms. From the survey of the literature on phytoplankton assemblages of Lake Burullus, there is a large variation among the researchers in the species composition and density depending on the surveyed station, water depth, sampling season, water quality, environmental condition and water pollution of the lake. The summing up of all the recorded species in these studies in one checklist indicate the presence of 276 algal species distributed among the algal groups as follows: 142 species of Bacillariophyta (55.3 %), 73 species of Chlorophyta (24.8 %), 51 species of Cyanophyta (17.2 %) and 10 species of other groups (2.7 %).

Bacillariophytes (i.e. diatoms) represented the major bulk of the phytoplankton biomass (69.0% of its total biomass), although it ranked numerically as the second important group (31.1% of the total phytoplankton counts). On the other hand, Chlorophytes came in the second order in case of the biomass (16.2%), but in the first order regarding the density (58.9% of the total counts). Cyanophytes contributed 14.8% of the total biomass and 8.8% of the total counts. The other groups had a minor contribution. The highest phytoplankton biomass was recorded in the western sector of the lake and the lowest in the eastern sector.

The monthly fluctuations of the total phytoplankton biomass indicated that the maximum biomass was attained in early autumn (September) in the eastern and middle sectors. Relatively high values were also recorded during winter (February) in the eastern sector and spring (March) in the Middle sector. On the other hand, the highest biomass in the western sector was recorded

during summer (June), beside smaller peaks in September and December. The temporal trend of the three major algal groups are quite similar. Regarding the phytoplankton production, Lake Burullus tends to mesotrophy. This may be attributed to the decreased amount of drain water flowing into the lake, and the increased density of the submerged hydrophytes, particularly *Potamogeton pectinatus*.The estimation of epiphytic algal communities growing on the hydrophytes in the Egyptian lakes is of prime importance in assessing their organic production. In Lake Burullus, *Potamogeton pectinatus* constituted about 85% of the total biomass of the submerged plants. The previous studies indicated the presence of 45 epiphytic species growing on this hydrophyte, most of them are limnetic forms, but can survive both planktonic and attached situations. These species are distributed among algal groups as follows: 27 Bacillariophytes (diatoms), 15 Chlorophytes, 12 Cyanophytes and 1 Rhodophyte.

The comparison between the phytoplankton communities of nine North African lakes (3 lakes in each of Egypt, Tunisia and Morraco), indicates that the three Egyptian lakes in Nile Delta (Manzalla, Burullus and Edku), which are alkaline sites with salinities less than 2 gm l^{-1}, are composed of cosmopolitan algal species and have larger density and more species diverse than the other lakes. Lake Burullus comes in the first regarding the density and diversity.

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5.6. PLATES OF PHYTOPLANKTON: 5.1 – 5.13

(after Palmer 1980)

Bacillariophyta (Diatoms): 5.1 – 5.5

<u>**Plate 5.1.**</u>
Fragilaria
Stephanodiscus
Achnanthes
Gomphonema parvulum
Gomphonema

<u>**Plate 5.2.**</u>
Cyclotella meneghiniana
Cyclotella

Navicula
Pinnularia
Surirella
Stauroneis

<u>**Plate 5.3.**</u>
Asterionella
Asterionella japonica
Melosira
Nitzschia closterium
Nitzschia palea

<u>**Plate 5.4.**</u>
Tabellaria flocculosa
Tabellaria
Chaetoceros
Cocconeis placentula
Cymbella

<u>**Plate 5.5**</u>
Melosira granulata
Navicula
Synedra
Synedra ulna

Chlorophyta: 5.6 – 5.10

Plate 5.6
Botryococcus braunii
Oocystis borgei
Scenedesmus
Scenedesmus quadricauda
Sphaerocystis schroeteri
Oedogonium

Plate 5.7
Ankistrodesmus falcatus var. acicularis
Ankistrodesmus falcatus
Chlamydomonas reinhardtii
Chlamydomonas
Phacotus lenticularis
Tetraedron

Plate 5.8
Chlorella
Closterium
Cosmarium
Dictyosphaerium

Plate 5.9
Elakatothrix
Golenkinia radiata
Pediastrum boryanum
Pandorina morum
Spirogyra

Plate 5.10
Eudorina
Cladophora
Carteria
Chodatella

Cyanophyta: 5.11 – 5.12

Plate 5.11
Lyngbya
Phormidium
Rivularia
Aphanizomenon

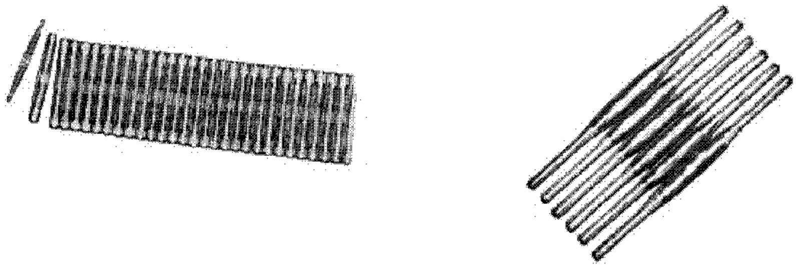
Plate 5.12
Spirulina
Anabaena
Oscillatoria

Euglenophyta
Plate 5.13
Phacus
Euglena

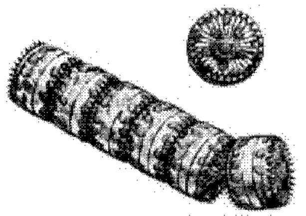
Rhodophyta
Compsopogon

Bacillariophyta (Diatoms)

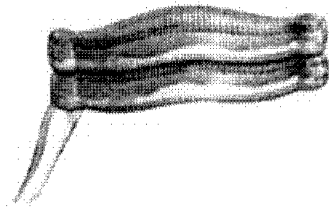
Plate 5.1



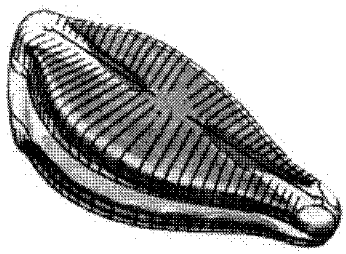
Fragilaria



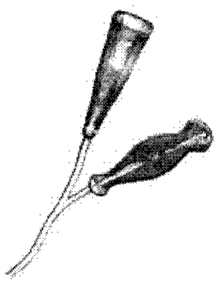
Stephanodiscus



Achnanthes

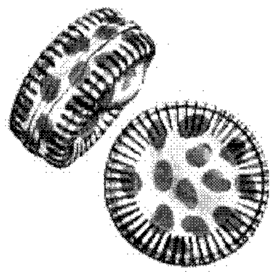


Gomphonema parvulum

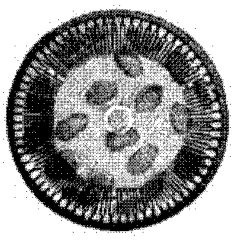


Gomphonema

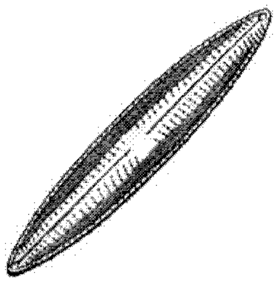
Plate 5.2



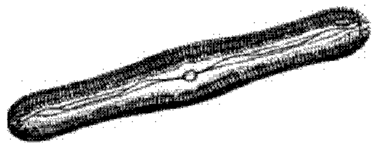
Cyclotella meneghiniana



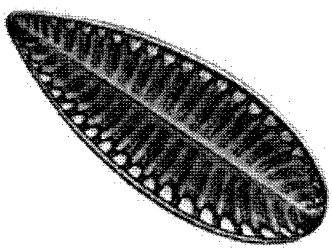
Cyclotella



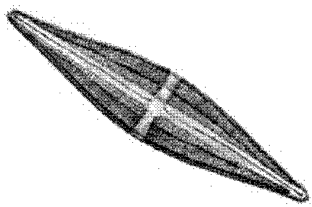
Navicula



Pinnularia

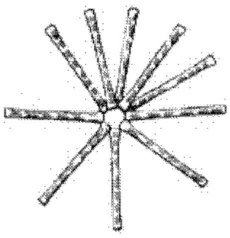


Surirella



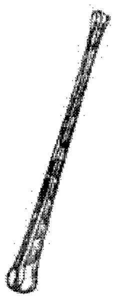
Stauroneis

Plate 5.3

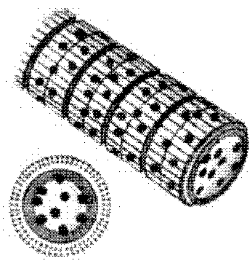


Asterionella

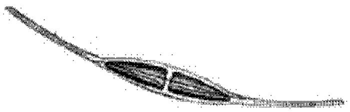
Asterionella japonica



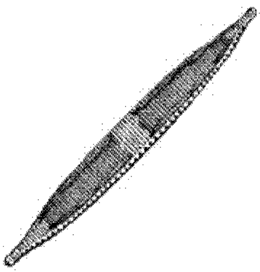
Asterionella



Melosira

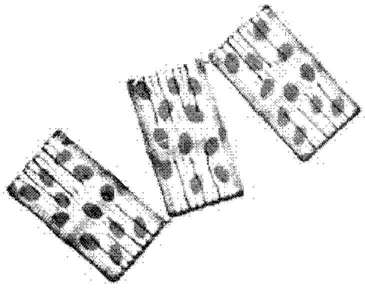


Nitzschia closterium

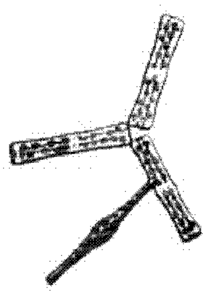


Nitzschia palea

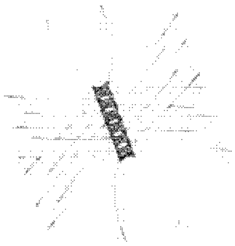
Plate 5.4



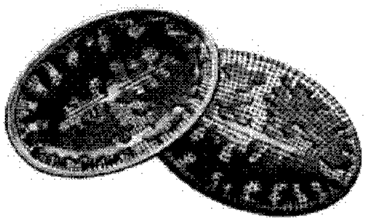
Tabellaria flocculosa



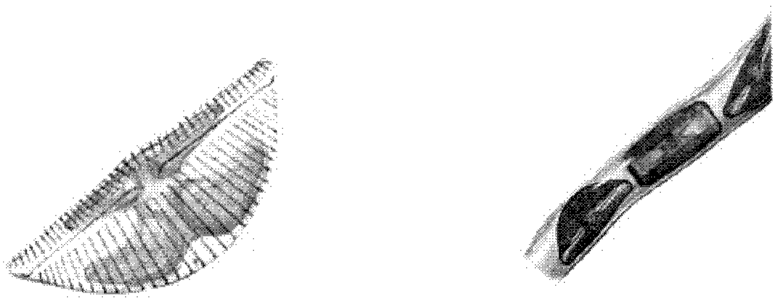
Tabellaria



Chaetoceros

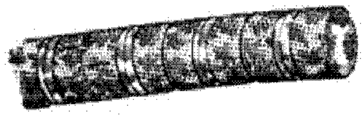


Cocconeis placentula

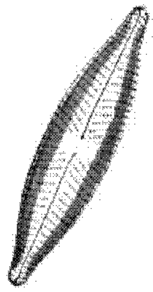


Cymbella

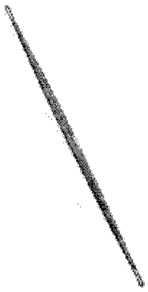
Plate 5.5



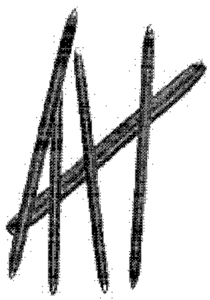
Melosira granulata



Navicula



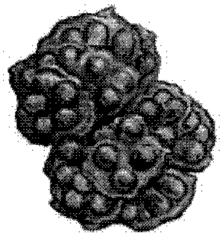
Synedra



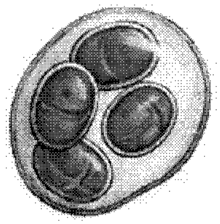
Synedra ulna

Chlorophyta

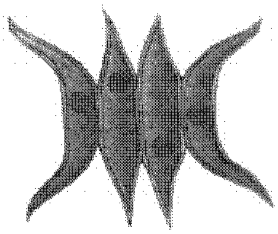
Plate 5.6



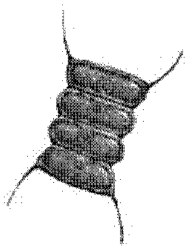
Botryococcus braunii



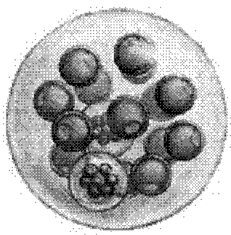
Oocystis borgei



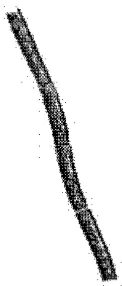
Scenedesmus



Scenedesmus quadricauda

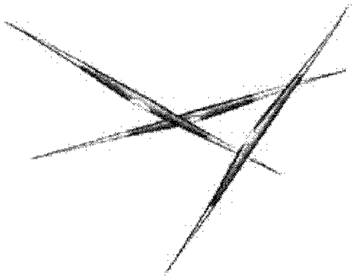


Sphaerocystis schroeteri

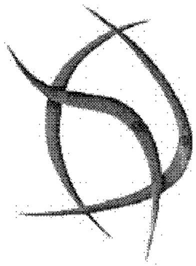


Oedogonium

Plate 5.7



Ankistrodesmus falcatus
var. acicularis



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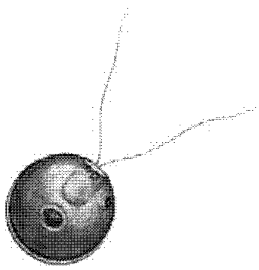
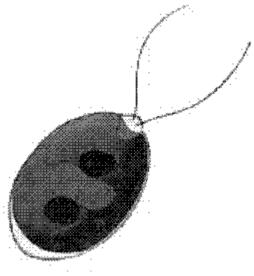
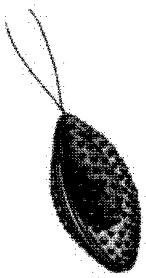


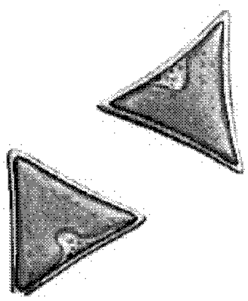
Chlamydomonas reinhardtii



Chlamydomonas

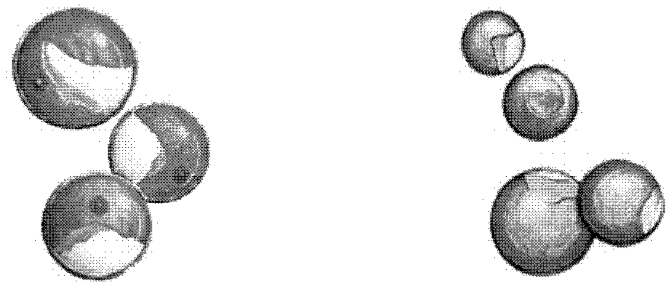


Phacotus lenticularis



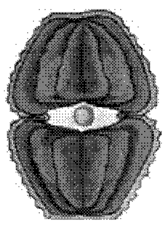
Tetraedron

Plate 5.8

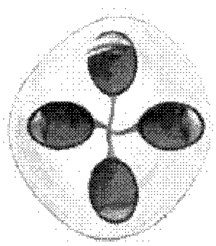


Chlorella

Closterium

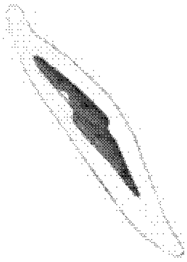


Cosmarium

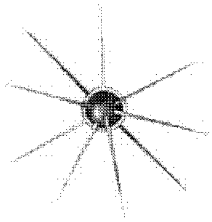


Dictyosphaerium

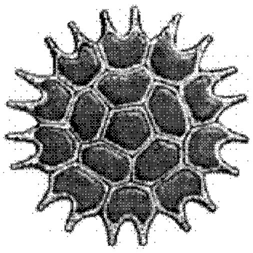
Plate 5.9



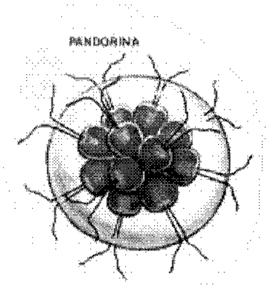
Elakatothrix



Golenkinia radiata



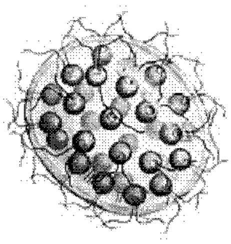
Pediastrum boryanum



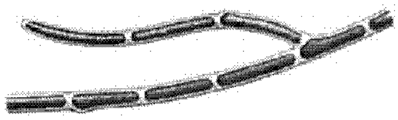
Pandorina morum

Spirogyra

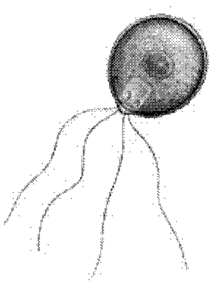
Plate 5.10



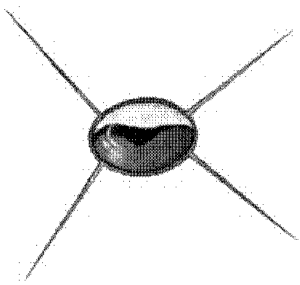
Eudorina



Cladophora



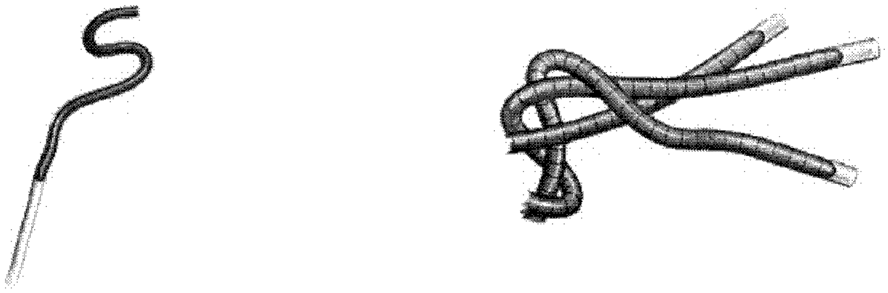
Carteria



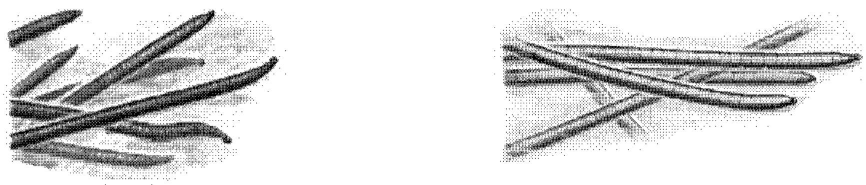
Chodatella

Cyanophyta

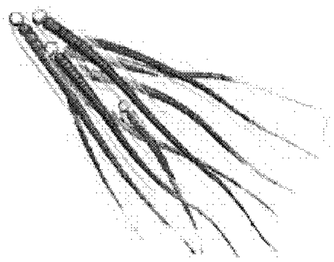
<u>Plate 5.11</u>



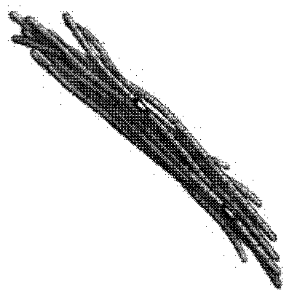
Lyngbya



Phormidium

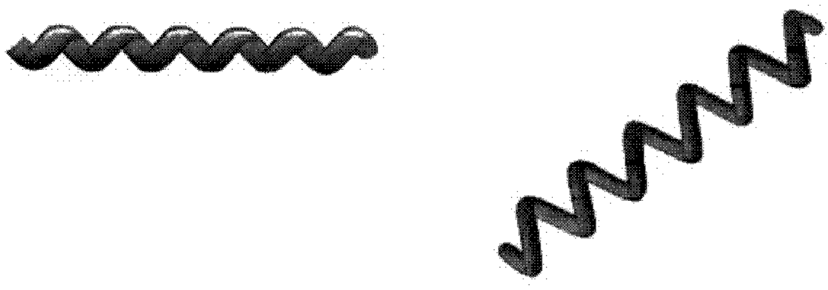


Rivularia

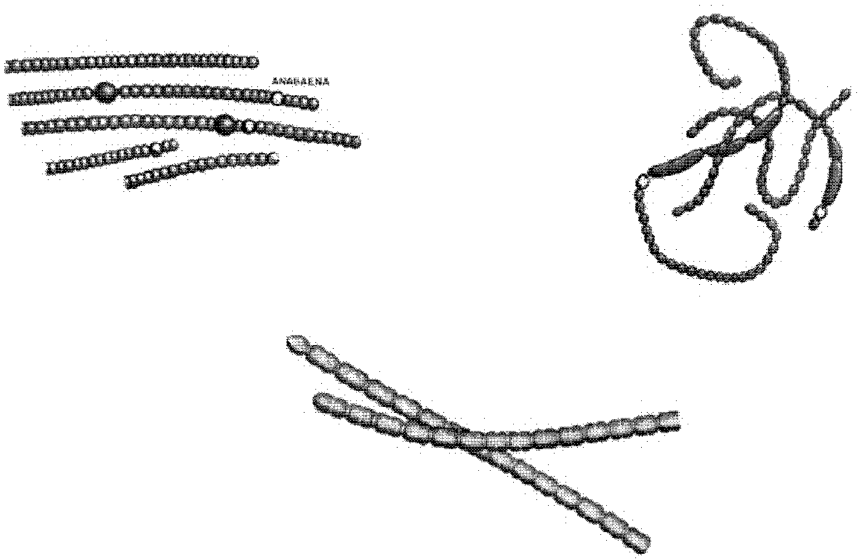


Aphanizomenon

Plate 5.12



Spirulina

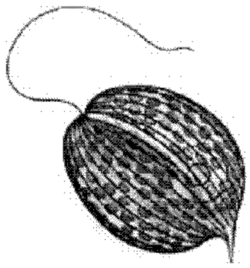


Anabaena

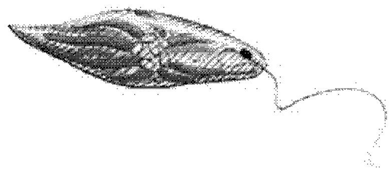
Oscillatoria

Plate 5.13

Euglenophyta

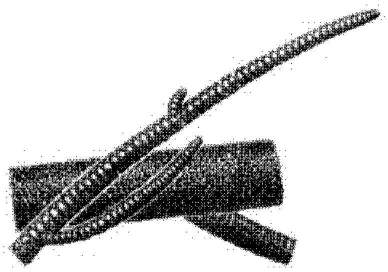


Phacus



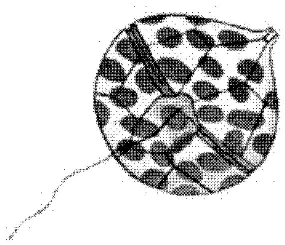
Euglena

Rhodophyta



Compsopogon

Dinophyta



Peridinium

Chapter 6
Bacteria and Fungi

6.1. SAPROTROPHISM

The aquatic bacteria, flagellates, and fungi are distributed throughout water bodies, but they are especially abundant in the mud-water interface along the bottom where bodies of plants and animals accumulate. While a few of the bacteria and fungi are pathogenetic in that they will attack living organisms and cause disease, the great majority begin attack only after the organism dies. When temperature conditions are favorable, decomposition occurs rapidly in a body of water; dead organisms do not retain their identification for very long, but are soon broken up into pieces, consumed by the combined action of detritus-feeding animals and microorganisms, and their nutrient released for reuse (Odum 1971).

Heterotrophy is the sole source of energy for most bacteria in lakes and some evidence suggests that large proportions of organic matter produced by the algae may be used by the bacterioplankton. The bacterioplankters are about the size of lentils, though with shapes varying from the familiar rods and cocci to filaments and branched prosthecate forms. They are suspended freely in the water as single cells or small colonies and commonly are studded onto a nucleus of dead organic detritus or other organisms. It is difficult to know at what population densities they occur because methods of study are in their infancy (Moss 1988).

The numbers or biomass of bacteria are not good measures of their activity for the turnover of the populations. Moreover, there is probably much specialization among the strains present. Some may metabolize mucose sugar polymers or one or more of the many carbohydrate polymers

found in algal cell walls; others may break down the chitins of crustacean exoskeletons and yet others may dissolve organic compounds secreted by phytoplankton (Moss 1988).

6.2. SEDIMENT AND THE OXIDIZED MICROZONE

In lakes, ponds and other standing waters, the many bacteria use organic detritus in the surface sediments as their energy source, and absorb much oxygen which is replaced by diffusion. Below this surface layer, called the oxidized microzone, bacterial activity uses up oxygen faster than it can be replaced and the sediment becomes anaerobic only a few mm below the surface. The oxidized microzone is usually brown-red in colour because it includes a large quantity of oxidized iron compounds: (largely oxide and hydroxide). Other substances are also present, especially ions like phosphate which are adsorbed and immobilized within the layer and largely prevented from diffusion into the overlying water. Below the oxidized microzone there is a great deal of bacterial activity for some centimeters. It is largely anaerobic, as different groups of bacteria, lacking access to oxygen and often unable to use it, use other electron accepters to oxidize organic matter (Moss 1988).

6.3. ACTINOMYCETES IN LAKE BURULLUS

Studies on the aquatic bacteria and fungi in Lake Burullus are limited. Only three studies are available to the authors (Mahmoud & abou Zeid 2002, Abou-Elela *et al.* 2004, El-Hissy *et al.* 2004). Actinomycetes can easily be isolated from fresh water and especially sediments of rivers and lakes (Al-Diwany and Cross, as quoted by Abou-Elela *et al.* 2004). The occurrence of these organisms in aquatic habitats means that they survive at these sites because most of them are endowed with spores or cells which show higher resistance toward unfavorable conditions than most bacteria.

The distribution of some groups of actinomycetes in Lake Burullus was investigated seasonally during the year 2003 by Abou-Elela *et al.* (2004). The diversity and counts of Streptomycetaceae, Actinoplanaceae and Nocardiopsaceae varied with the seasonal variation. Streptomycetaceae was the dominant group where its highest counts were detected in El-Znaka station in summer and spring (dry warm seasons). Stepwise multiple regression analysis revealed that the distribution of these groups was affected by some environmental factors such as temperature, organic matter and sediment nature, but there was no significant difference in the actinomycetales count along the studied area in the lake during different seasons.

6.4. ZOOSPORIC FUNGI IN LAKE BURULLUS

Mahmoud & Abou Zeid (2002) recorded 11 zoosporic fungal species in the surface water of Lake Burullus, in comparison with 15 species in Lake Manzala, 14 in Qaron and 10 in Edku. El-Hissy *et al.* (2004) studied the diversity of zoosporic fungi from the surface water of four Egyptian lakes: Burullus and Manzala in the north, Qaron in the mid and Nasser in the south. They identified 36 species in addition to 4 unidentified species and only one variety belonging to 11 genera of zoosporic fungi. Lake Burullus was the second most diverse lake (after Manzala), where 14 identified species, in addition to 3 unidentified species and one variety, were recorded. These taxa belong to 9 genera. Four genera: *Pythium*, *Phytophthora*, *Saprolegnia* and *Aphanomyces* were the commonest zoosporic fungi isolated from the surface water of Lake Burullus. *Phytophthera* is represented by the highest number of species (4 species and one variety), while *Allomyces*, *Aqualinderella*, *Blastocladia* and *Dictyuchus* were represented by only one species (Table 6.1).

Table 6.1. **Actual (Ac: out of 19 samples) and relative (Re: %) number of cases of isolation (NCI) of zoosporic fungal genera and species recoded from 19 surface water samples randomly collected from Lake Burullus (adapted from El-Hissy *et al.* 2004).**

Taxa	NCI		Taxa	NCI	
	Ac	Re		Ac	Re
Achlya	**4**	**21.1**	***Phytophthora***	**7**	**36.8**
A. conspicua	3	15.8	*P. cactorum var. applanata*	1	5.3
A. flagellata	2	10.5	*P. cambivora*	1	5.3
Allomyces	**3**	**15.8**	*P. cinnamomi*	3	15.8
A. macrogynus	3	15.8	*P. omnivora*	1	5.3
Aphanomyces	**6**	**31.6**	*P. primulae*	1	5.3
A. laevis	5	26.3	***Pythium***	**9**	**47.4**
A. species	1	5.3	*P. pulchrum*	1	5.3
Aqualinderella	**3**	**15.8**	*P. thalassium*	3	15.8
A. fermentans	3	15.8	*P.* species	6	31.6
Blastocladia	**1**	**5.3**	***Saprolegnia***	**6**	**31.6**
B. bringsheim	1	5.3	*S. diclina*	2	10.5
Dictyuchus	**1**	**5.3**	*S.* species	5	26.3
D.monosporus	1	5.3			

6.5. SUMMARY

The studies on the aquatic bacteria and fungi in Lake Burullus are limited. The distribution of some groups of actinomycetes in Lake Burullus was investigated seasonally during the year 2003. The diversity and counts of Streptomycetaceae, Actinoplanaceae and Nocardiopsaceae varied with the

seasonal variation. Streptomycetaceae was the dominant group. The distribution of these groups was affected by some environmental factors such as temperature, organic matter and sediment nature. The diversity of zoosporic fungi from the surface water of four Egyptian lakes: Burullus and Manzala in the north, Qaron in the mid and Nasser in the south was studied in 2004. 36 species in addition to 4 unidentified species and only one variety belonging to 11 genera of zoosporic fungi were identified. Lake Burullus was the second most diverse lake (after Manzala), where 14 identified species, in addition to 3 unidentified species and one variety, were recorded.

6.6. REFERENCES

Aboo-Elela, G., Ghanem, N. & Okbah, M. 2004. Distribution of some actinomycetes groups in Burullus Lake. Bull. Fac. Sci., Assiut Univ., In Press.

El-Hissy, F., Ali, E. & Abdel-Raheem, A. 2004. Diversity of zoosporic fungi recovered from the surface water of four Egyptian lakes. Ecohydrology & Hydrobiology, 4 (1): 77-84.

Mahmoud, Y.A. & Abou Zeid, A.M. 2002. Zoosporic fungi isolated from four lakes and the uptake of radioactive waste. Mycology, 30(2): 76-81.

Moss, B. (1988). Ecology of fresh waters: Man and Medium. Blackwell Science, London, 417 pp.

Odum, E.P. (1971). Fundamentals of Ecology. W.B. Saunders Company, Philadelphia.

Chapter 7
Zooplankton

Zooplankton community is an important trophic level both in grazing and nutrient regeneration of phytoplankton and as food for juvenile and adult fishes. The study of zooplankton distribution is also useful for the general monitoring of certain aspects of the environment such as hydrographic events, pollution, eutrophication, warming trends and long-term changes which are signs of environmental disturbance. Aboul-Ezz (1984) studied the monthly variation and community structure of zooplankton and benthos of Lake Burullus during late seventies. She mentioned that Copepoda group dominated the other taxa, forming 68.4% and 36.8% during 1978 and 1979, where it was represented by 44 and 34 species, respectively; 8 species of them were marine in origin. El-Sherif and Aboul-Ezz (1988) studied zooplankton-phytoplankton relationship in Lake Burullus, and stated that both zooplankton and phytoplankton had a linear relationship in the western sector, which harbored the highest standing stock of both. The consumption rate of phytoplankton by zooplankton was less pronounced, reflecting the eutrophic condition of the lake. Aboul-Ezz (1995) mentioned that zooplankton population in the lake showed a remarkable increase during 1987 – 1988 (183,000 ind. m^{-3}), when compared with that recorded during 1978 – 1979 (111,000 and 45,000 ind. m-3, respectively). Copepoda dominated the other groups (36.6 %) and were represented by 26 species, Cladocera and Rotifera came next (21.8 and 15.5 % respectively) and was represented by 7 and 26 species, respectively. Ramdani et al. (2001) included the zooplankton of Lake Burullus in their study on the open water zooplankton communities in north African wetland lakes.

El-Shabrawy (2002 & 2004) studied the biodiversity, density and population dynamics of zooplankton in Lake Burullus at 11 stations (Fig. 7.1), before and after the implementation of the management plan of the Lake.

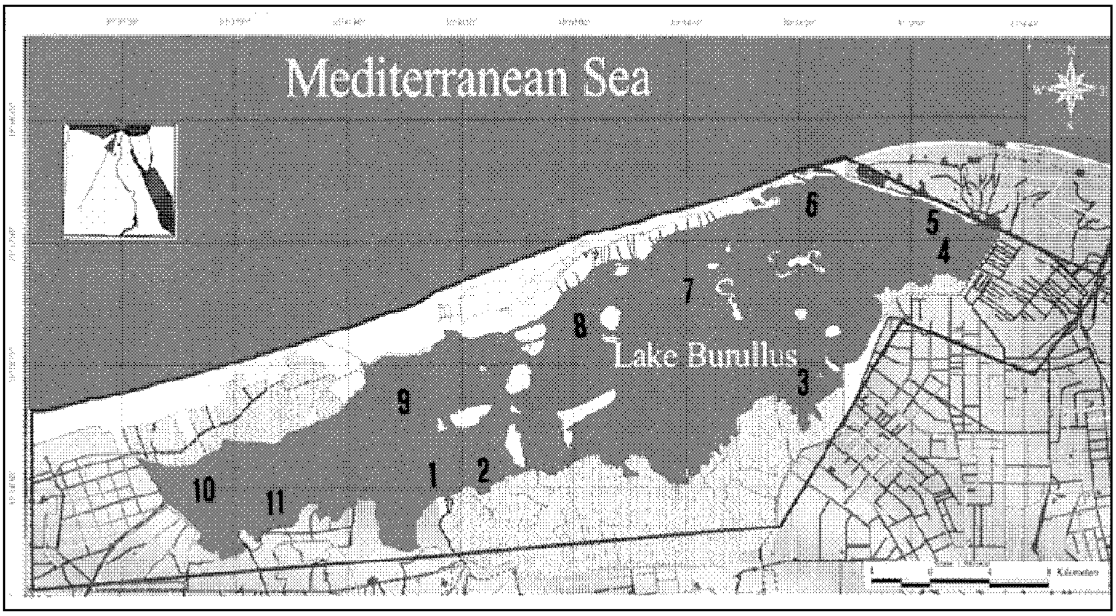


Fig 7.1. **Map of Lake Burullus showing the location of sampling sites (El–Shabrawy 2002 and 2004)**

7.1. PRESENT STATUS OF ZOOPLANKTON

A total of 75 zooplankton species belonging to 3 main groups (Rotifera, Copepoda and Cladocera) in addition to 8 protozoan and 4 meroplankton species were recorded during 2003/04 (El-Shabrawy 2004) (Table 7.1). It is worth mentioning that some marine species were redetected at the northern area of the Lake, near El-Boughaz, after implementation of the management plan in 2002. These species include: two of Protozoa (*Eutintinnus lusus-undae* and *Metacylis mediterrnean*), and five of Copepoda (*Oithona nana, Paracalanus parvus, Euterpina acutifrons, Harpacticus* sp. and *Macrosrtella gracillis*).

7.1.1. Newly recorded species for Lake Burullus

Four zooplankton species were recorded for the first time in Lake Burullus in 2003-04 (El-Shabrawy 2004), these are two of Rotifera (*Lecane arcula* and *Trichocerca inermis*), one of Copepoda (*Harpacticus* sp.) and one of Cladocera (*Diaphanosoma mongolanium*).

Table 7.1. **Checklist of the zooplankton species recorded in Lake Burullus during different time periods. F. W.: Freshwater species, M. W.: Marine water species.**

Species	Abou-Ezz (1984)		Abou-Ezz (1995)	El-Shabrawy (2002)	El-Shabrawy (2004)	Habitat
	1978	1979	1987 1988	2001 2002	2003 2004	
Rotifera						
Anuraeopsis fissa (Gosse)	--	--	--	+	+	F.W.
Asplanchna girodi De Guerne	--	--	--	+	+	F.W.
Asplanchna priodonta Gosse	+	+	+	--	--	F.W.
Asplanchna sieboldi Leydig	--	--	--	+	+	F.W.
Brachionus angularis Gosse	+	+	+	+	+	F.W.
Brachionus budapestinensis Daday	--	--	+	+	+	F.W.
Brachionus calyciflorus Pallas	+	+	+	+	+	F.W.
Brachionus caudatus (Barrois &Daday)	+	+	+	+	+	F.W.
Brachionus falcatus Zacharias	--	--	+	--	--	F.W.
Brachionus plicatilis (Müller)	+	+	--	+	+	F.W.
Brachionus quadridentatus Hermann	+	+	+	+	+	F.W.
Brachionus rubens Ehr.	--	--	--	+	+	F.W.
Brachionus urceolaris (Müller)	+	+	+	+	+	F.W.
Cephalodella gibba Ehr.	--	--	--	+	+	F.W.
Cephalodella megalocephala Glascott	+	+	+	--	--	F.W.
Colurella adriatica Carlin	+	+	--	+	+	F.W.
Colurella obtusa Haver	+	+	--	--	+	F.W.
Filinia longiseta Ehr.	--	--	+	+	+	F.W.
Harringia rouseleti Beauchamp.	+	--	--	+	+	F.W.
Hexarthra oxyuris Hudson	--	--	--	+	+	F.W.
Kellicottia longispina Kellicott	--	+	--	--	--	F.W.
Keratella cochlearis Gosse	+	+	+	+	+	F.W.
Keratella quadrata Müller	+	+	+	+	+	F.W.
Keratella tropica Apstein	+	+	+	+	+	F.W.
Keratella vulga Ehr.	+	+	+	+	+	F.W.
Lecane arcula Harring	--	--	--	--	+	F.W.
Lecane bulla Gosse	--	+	+	+	+	F.W.
Lecane closterocera Schmarda	+	+	--	--	+	F.W.
Lecane depressa Müller	+	+	--	--	--	F.W.
Lecane elasma Harring & Myers	+	+	--	--	--	F.W.
Lecane luna Müller	+	+	+	+	+	F.W.
Lecane lunaris Ehr.	--	+	+	--	+	F.W.
Lecane ohioensis Müller	+	+	--	--	--	F.W.

Table 7.1. Cont.1

Species	Abou-Ezz (1984)		Abou-Ezz (1995)	El-Shabrawy (2002)	El-Shabrawy (2004)	Habitat
	1978	1979	1987 1988	2001 2002	2003 2004	
Lepadella ovalis Müller	+	+	--	--	--	F.W.
Lepadella patella Müller	+	+	+	--	+	F.W.
Macrochaetus nearsubquadratus Petry	+	+	+	--	--	F.W.
Philodina roseola Ehr.	--	--	--	+	+	F.W.
Polyarthra ramata Skorikow	--	--	--	+	+	F.W.
Polyarthra vulgaris Carlin	+	+	+	+	+	F.W.
Proalides sp.	--	--	--	+	+	F.W.
Pseudoharringia similis Fadeau	--	+	--	--	--	F.W.
Pseudoploesoma formosum Myers	--	+	--	--	--	F.W.
Rhinoglena frontalis Ehr.	--	+	--	--	--	F.W.
Rotatoria sp.	--	--	+	+	+	F.W.
Synchaeta oblonga Ehr.	+	+	+	+	+	F.W.
Synchaeta pectinata Ehr.	+	+	+	+	+	F.W.
Testudinella patina Hermann	--	--	--	+	+	F.W.
Trichocerca cylindrica Imhof	+	+	+	+	+	F.W.
Trichocerca elongata Gosse	--	--	--	+	--	F.W.
Trichocerca gracilis Tessin	--	--	--	+	+	F.W.
Trichocerca pusilla Jennings	--	--	--	+	+	F.W.
Trichocerca inermis Linder	--	--	--	--	+	F.W.
Tripleuchlanis plicata Carlin	+	+	+	--	--	F.W.
Copepoda						
Acanthocyclops americanus March	+	+	+	+	+	F.W.
Acanthocyclops exilis Coker	+	+	+	--	--	F.W.
Acanthocyclops vernalis Fischer	+	+	+	--	--	F.W.
Acartia latisetosa Kriczaguin	+	+	+	--	--	M.W.
Apocyclops panamensis March	--	--	--	+	+	F.W.
Bryocamptus hiemalis Pearse	+	--	--	--	--	F.W.
Calanus brevicornis Lubbock	+	--	--	--	--	M.W.
Canthocamptus dentatus Poggenpol	+	+	--	--	--	F.W.
Canthocamptus gracilis Sars	+	--	+	--	--	F.W.
Canthocamptus proegeri Scourfield	+	--	+	--	--	F.W.
Canthocamptus pygmaens Sars	+	--	+	--	--	F.W.
Canuella perplexa Scot	--	--	+	--	--	M.W
Centropages sp.	--	--	+	--	--	M.W.
Cyclops capillatus Sars	+	+	+	--	--	F.W.

Table 7.1. Cont.2

Species	Abou-Ezz (1984)		Abou-Ezz (1995)	El-Shabrawy (2002)	El-Shabrawy (2004)	Habitat
	1978	1979	1987 1988	2001 2002	2003 2004	
Cyclops crassicaudis Sars	+	+	--	--	--	F.W.
Cyclops magnus March	+	+	--	--	--	F.W.
Cyclops scutifer Sars	+	+	--	--	--	F.W.
Cyclops sepratus Lilljeborg	+	+	+	--	--	F.W.
Cyclops strennus Fischer	+	+	+	--	--	F.W.
Cyclops varicans Lilljeborg	+	+	--	--	--	F.W.
Cyclops venustus Norman & Scott	+	+	--	--	--	F.W.
Cyclops vicinus Uljanin	+	+	--	--	--	F.W.
Diacyclops bicuspidatus Claus	+	+	+	--	--	F.W.
Diaptomus gracilis Sars	--	--	+	--	--	F.W.
Diaptomus marshianus M.S. Wilson	+	+	--	--	--	F.W.
Diaptomus minutus Lilljeborg	+	+	+	--	--	F.W.
Diaptomus purpureus Harsh	+	+	--	--	--	F.W.
Diaptomus saltillinus Brewer	+	+	--	--	--	F.W.
Eucyclops agilis Koch	+	+	+	--	--	F.W.
Eucyclops prionophorus Kiefer	+	+	--	--	--	F.W.
Ergasilus sieboldi Norman	+	--	+	--	--	F.W.
Euterpina acutifrons Dona	--	+	+	--	+	M.W
Halicyclops magniceps Sars	+	+	+	--	--	F.W.
Horsiella brevlicornis Van Dauwe	+	+	--	--	--	F.W.
Harpacticus sp.	--	--	--	--	+	M.W.
Isias clavipes Boeck	+	--	--	--	--	M.W.
Macrocyclops albidus Jurine	--	--	--	+	+	F.W.
Macrosetella gracilis Dona	+	--	+	--	+	M.W
Maraenobiotus vejdovskyi Gurney	+	--	--	--	--	F.W.
Mesochra rapiens Schmeil	+	+	--	--	--	F.W.
Mesocyclops leuckarti Claus	+	+	+	--	--	F.W.
Nitocra lacustris Schmankevitch	+	+	+	+	+	F.W.
Oithona helgolandica Claus	+	+	--	--	--	M.W.
Oithona nana Giesb	+	+	+	--	+	M.W.
Oithona robusta Giesb	+	+	--	--	--	M.W.
Oncychocamptus mohamed Blanchard	+	+	+	--	--	F.W.
Paracalanus parvus Claus	+	--	--	--	+	M.W.
Paracyclops fimbriatus Poppei	+	+	--	--	--	F.W.
Schizopera clandestina Kile	+	--	+	--	--	F.W.

Table 7.1. Cont.3

Species	Abou-Ezz (1984)		Abou-Ezz (1995)	El-Shabrawy (2002)	El-Shabrawy (2004)	Habitat
	1978	1979	1987 1988	2001 2002	2003 2004	
Schizopera nilotica	--	--	--	+	+	F.W.
Tachidius descipes Geisb	+	--	--	--	--	F.W.
Thermocyclops crassus Fischer	--	+	+	--	+	F.W.
Thermocyclops decipinis Kieker	--	--	--	+	+	F.W.
Thermocyclops neglectus Sars	--	--	--	+	+	F.W.
Nauplius larvae	+	+	+	+	+	F.W.
Copepodid stages	+	+	+	+	+	F.W.
Cladocera						
Alona intermedia Sars	+	+	+	--	--	F.W.
Alonella nana Baird	+	+	--	--	--	F.W.
Bosmina longirostris Muller	+	+	+	+	+	F.W.
Ceriodaphnia reticulata Jurine	+	+	+	--	+	F.W.
Chydorus ovalis Kurz	--	+	+	--	--	F.W.
Chydorus sphaericus Muller	--	--	--	+	+	F.W.
Daphnia similis Claus	--	--	--	+	+	F.W.
Diaphanosoma brachynrum Lieven	+	+	--	--	--	F.W.
Diaphanosoma mongolianum	--	--	--	--	+	F.W.
Diaphanosoma excisum Sars	+	+	+	+	+	F.W.
Ilyocryptus agilis Kurz	--	--	--	+	+	F.W.
Macrothrix laticornis Jurine	--	--	--	+	+	F.W.
Macrothrix rosea Jurine	+	+	--	--	--	F.W.
Moina micrura Kruz	+	+	+	+	+	F.W.
Oxyurella longicaudis Birge	+	+	+	--	--	F.W.

7.2. DISTRIBUTION OF COMMON SPECIES

7.2.1. Rotifera

7.2.1.1. *Keratella quadrata*

K. quadrata has been found to be the most dominant rotifer species of zooplankton community in Lake Burullus, forming 34.3 % of the total rotifers. The highest standing crop of 1950000 ind. m^{-3} was observed in the west area during winter, while it was completely missing in summer and autumn (Fig. 7.2). Aboul-Ezz (1995) recorded it with a maximum yield in winter in the Lake. El-Shabrawy (1999) considered it the most dominant plankters in Wadi El-Rayan Lakes. Moreover, it was represented mainly during October in the River

Nile (Ahmed 2000), and only seen during spring and autumn in Damietta Nile branch (El-Bassat 2002). *K. quadrata* is a cosmopolitan species in fresh and brackish waters (Shiel *et al.* 1982).

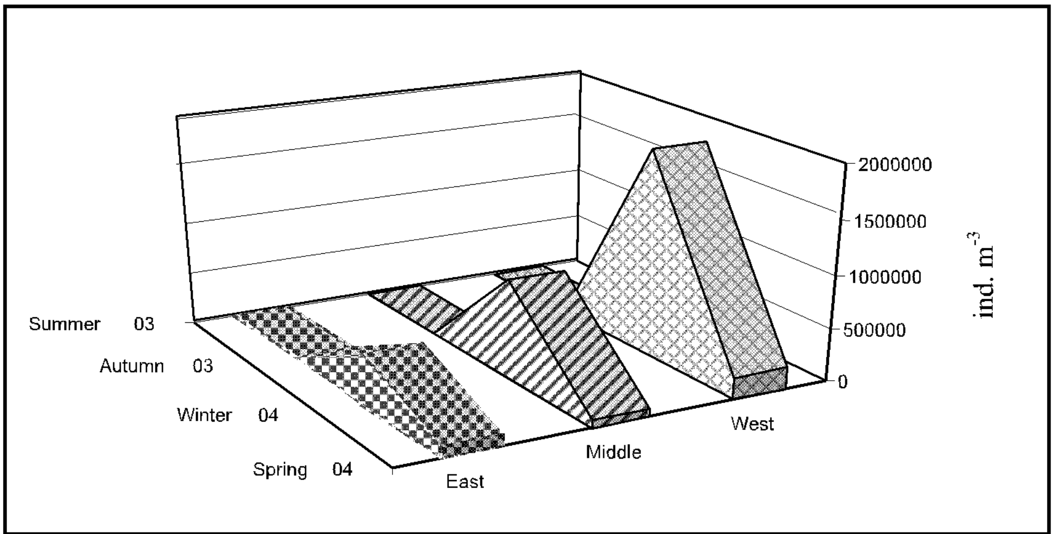


Fig. 7.2. **Standing crop of *Keratella quadrata* in Lake Burullus during 2003-2004.**

7.2.1.2. *Brachionus calyciflorus*

B. calyciflorus is one of the most dominant plankters, occupying the 2nd position and forming 21.5% of the total rotifers count. The west area of the lake maintained the highest density, with peak of 690000 ind. m^{-3} in summer (Fig. 7.3). *B. calyciflorus* was previously recorded from most of the Egyptian fresh waters. It is considered an indicator for eutrophic water (Guisande & Joja 1988), being cosmopolitan, eurythermal, euryhaline in alkaline and also polluted shallow waters (Shiel *et al.* 1982).

7.2.1.3. *Brachionus angularis*

Brachionus angularis occupied the third dominance position among rotifers, forming 15.3 % of the total rotifers community. During this survey, it was perennially reported in the different lake areas. The highest crop was at the west area during summer and autumn (330000 and 270000 ind. m^{-3}) (Fig. 7.4). *B. angularis* was previously recorded in Lake Burullus with a distinct peak in winter (Aboul-Ezz 1984), and with a high density during September and October in River Nile at Helwan (Ahmed 2000), forming 25 % of the total genus at El-Serw area of Damietta Nile branch (El-Bassat 2002). Bartos (1959) reported that *B. angularis* was a perennial species, prefering alkaline water, with littoral vegetation. Moreover, it occurs in most eutrophic waters (Sladecek 1983).

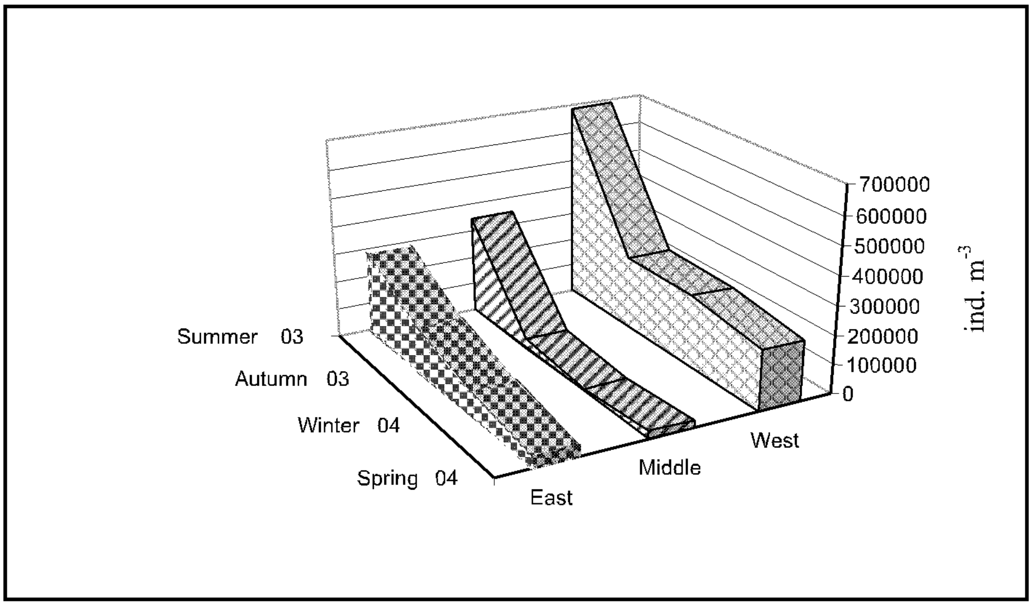


Fig. 7.3. **Standing crop of *Brachionus calyciflorus* in Lake Burullus during 2003-2004.**

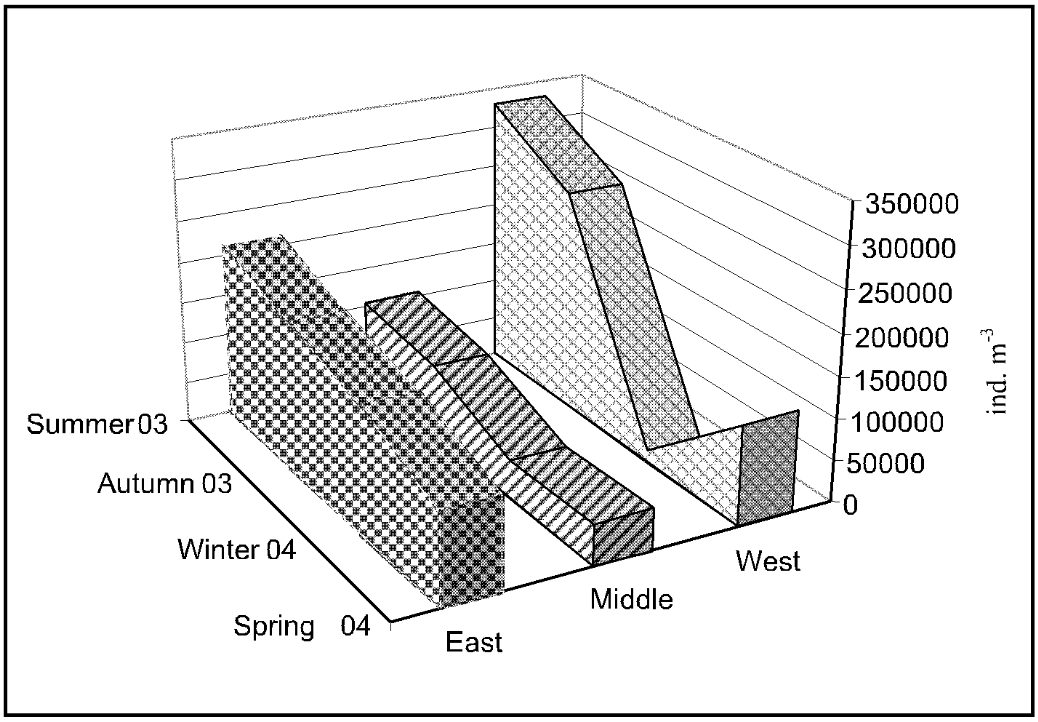


Fig. 7.4. **Standing crop of *Brachionus angularis* in Lake Burullus during 2003-2004 (El-Shabrawy 2004).**

7.2.1.4. *Polyarthra vulgaris*

Polyarthra vulgaris represents the second example for dominant rotifer plankters in the lake. This species was highly represented during summer, with a major peak of 150,000 ind. m^{-3} in the middle area (Fig. 7.5). The maximum density of this species occurred in spring in River Nile and Damietta Nile branch (Ahmed 2000 and El-Basat 2002, respectively). Attayge and Bonzlli (1998) considered it as a good indicator of eutrophication.

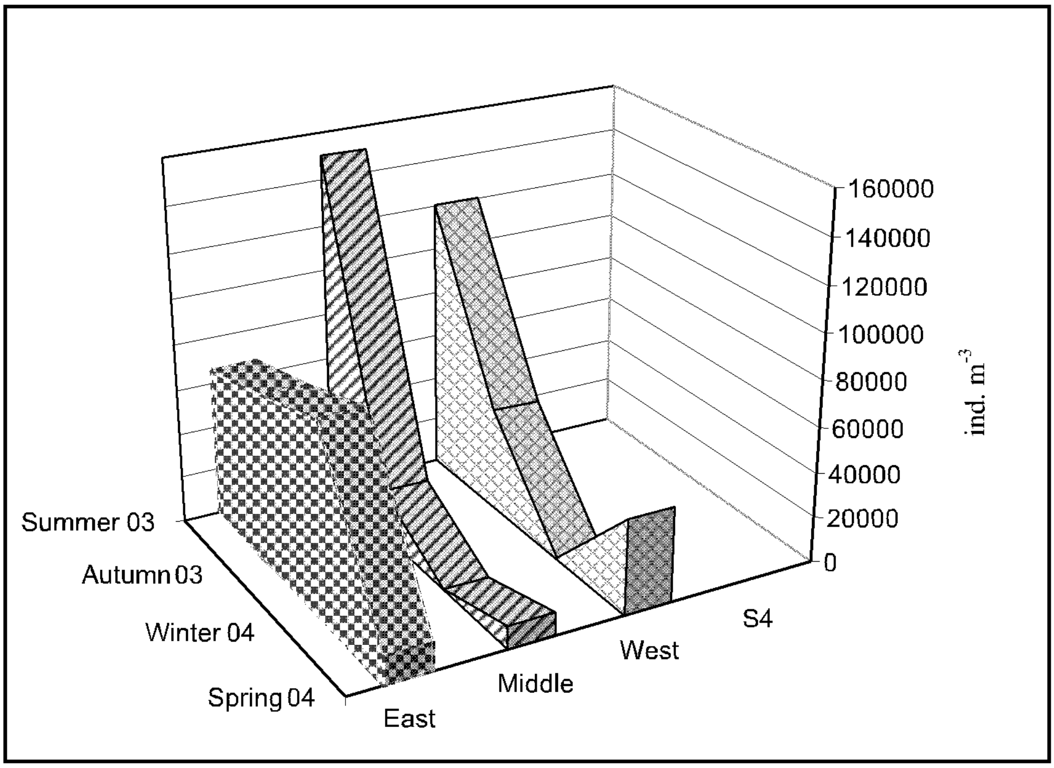


Fig. 7.5. **Standing crop of *Polyarthra vulgaris* in Lake Burullus during 2003-2004.**

7.2.1.5. *Brachionus plicatilis*

This species is one of the dominant species, that can be regarded as a typical summer plankter. The maximum density occurred in summer, with a major peak of 300,000 ind. m^{-3} at the east area. It was rare or even absent from the majority of stations in autumn and winter (Fig. 7.6). El-Shabrawy (2002) stated that *B. plicatilis* reached its maximum density in Lake Qarun during summer, while it was rare or even missing in winter and spring counts. It was previously recorded in River Nile at Helwan with gradual increase from May to August (Ahmed 2000), and it was recorded in Wadi El-Rayan as a predominant among 23 rotiferan species (El-Shabrawy 1999). It contributed 0.6% of the total genus count at El-Serw area (Damietta Nile Branch; El-Bassat 2002). This species also has been recorded in Rosetta Nile Branch (Aboul-Ezz 1995). The

highest density of this species was confined to July in Lake Mariut (Abdel-Aziz 1987). *B. plicatilis* is a cosmopolitan species, though restricted to alkaline waters and is considered as a brackish water species as well as marine inhabitant.

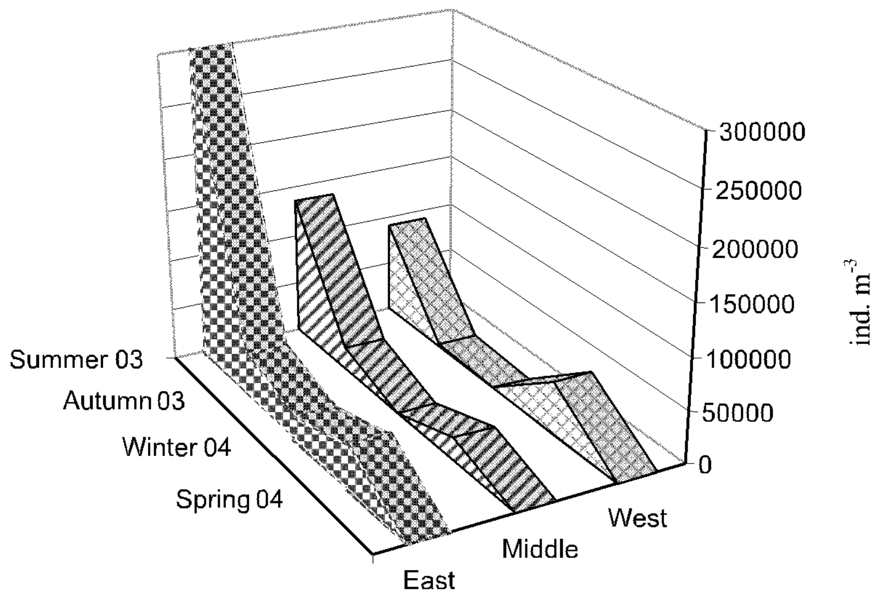


Fig. 7.6. **Standing crop of *Brachionus plicatilis* in Lake Burullus during 2003-2004 (El-Shabrawy 2004).**

7.2.1.6. *Filinia longiseta*

This species was reported to be an aestival plankter, owing to its highest occurrence in summer (Fig. 7.7). It is considered as a truly planktonic organism which indicates mesotrophic or eutrophic conditions (Gannon and Stenberger 1978). It has a wide geographical distribution, being found in large numbers of eutrophic Indian waters and the rivers of Europe. It was recorded in lakes of White Nile, Blue Nile and in Nile water. In Egypt, it has been formerly reported from Lake Nasser (Zaghloul 1985), Edku (Samman 1976), Mariut (Abdel-Aziz 1987), and Rosetta Nile Branch (Aboul-Ezz 1995).

7.2.2. Copepoda

7.2.2.1. *Acanthocyclops americanus*

A. americanus is the most dominant copepod plankter in Lake Burullus The population density of this species reached its maximum in winter, with a major peak of 15,000 ind. m^{-3} at the middle of the lake (Fig. 7.8). Aboul-Ezz (1995) recorded this species with its maximum frequency in winter and spring in

Lake Burullus. This agrees with Samaan (1976); Guerguess (1979); Abdel-Aziz (1987) and El-Shabrawy (2004).

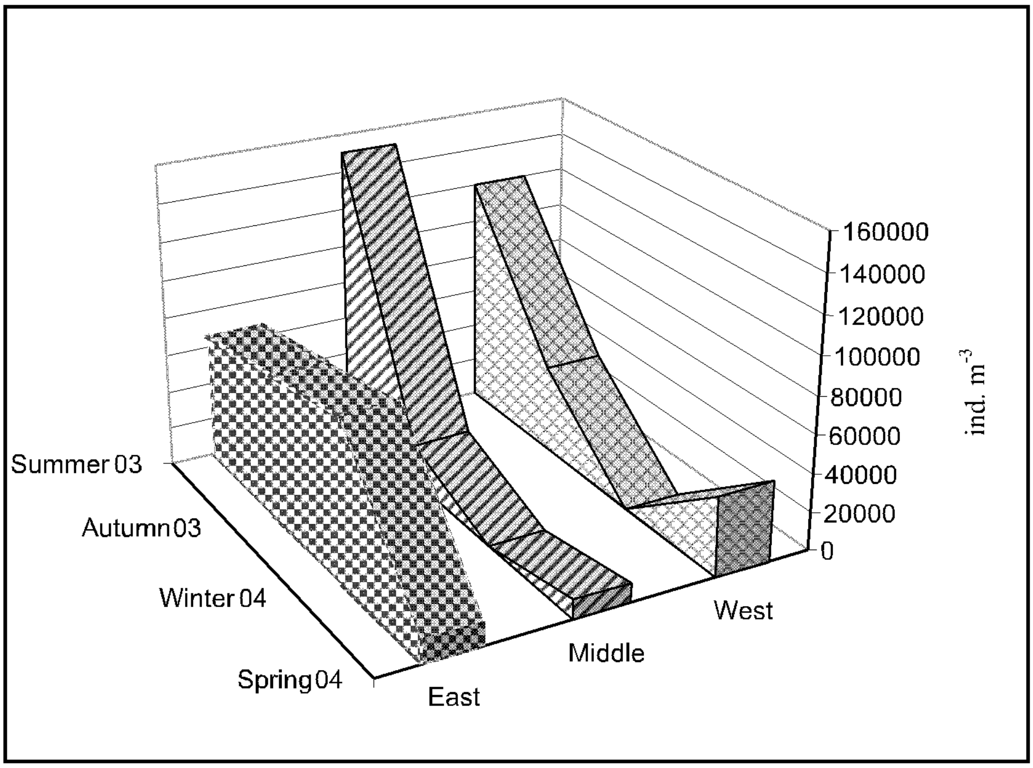


***Fig. 7.7.* Standing crop of *Filinia longiseta* in Lake Burullus during 2003-2004 (El-Shabrawy 2004).**

7.2.2.3. *Apocyclops panamensis*

A. panamensis is a moderately common species in Lake Burullus. It weakly exists during winter, but widely spread in summer, with a peak of 18,000 ind. m^{-3} at the middle of the lake (Fig. 7.9).

7.2.3. Cladocera

7.2.3.1. *Moina micrura*

M. micrura is a perennial species, monopolized other cladocerans and forming 78.7 % of their total count. The population density of this species attained its maximum level in summer with a pinnacle of 540000 ind. m^{-3} at the middle of the lake. It was faintly represented in winter (Fig. 7.10). Aboul-Ezz (1995) mentioned that *M. micrura* dominated the other Cladocera and reached its maximum during autumn and summer in Lake Burullus.

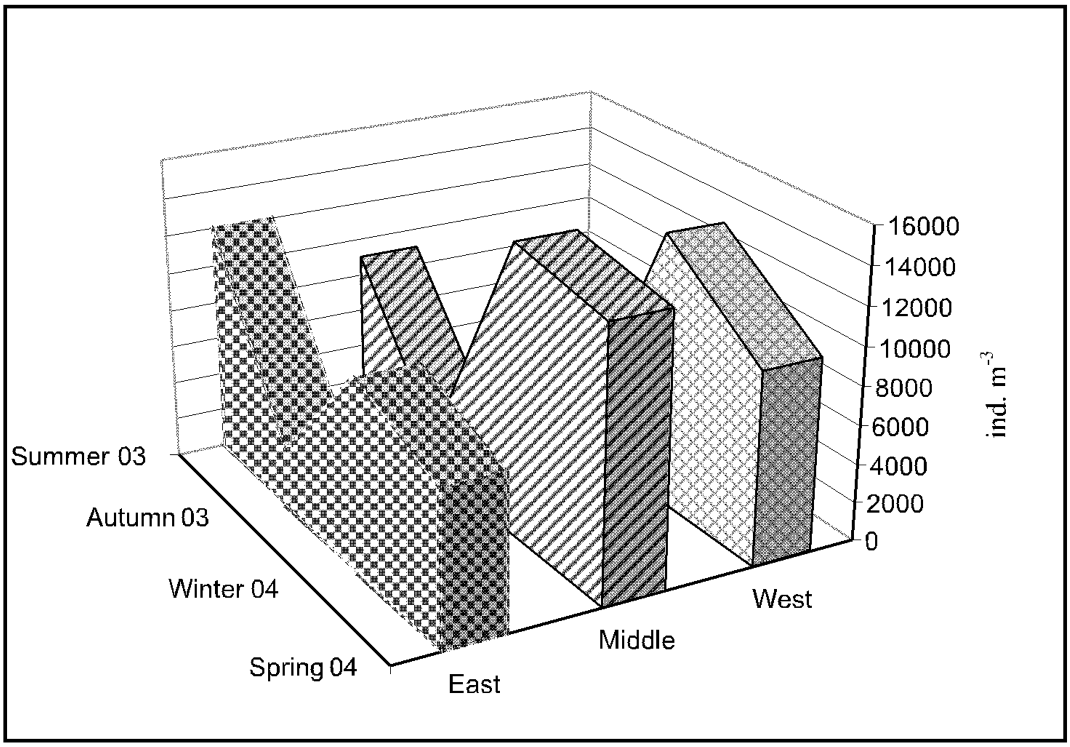


Fig. 7.8. **Standing crop of *Acanthocyclops americanus* in Lake Burullus during 2003-2004.**

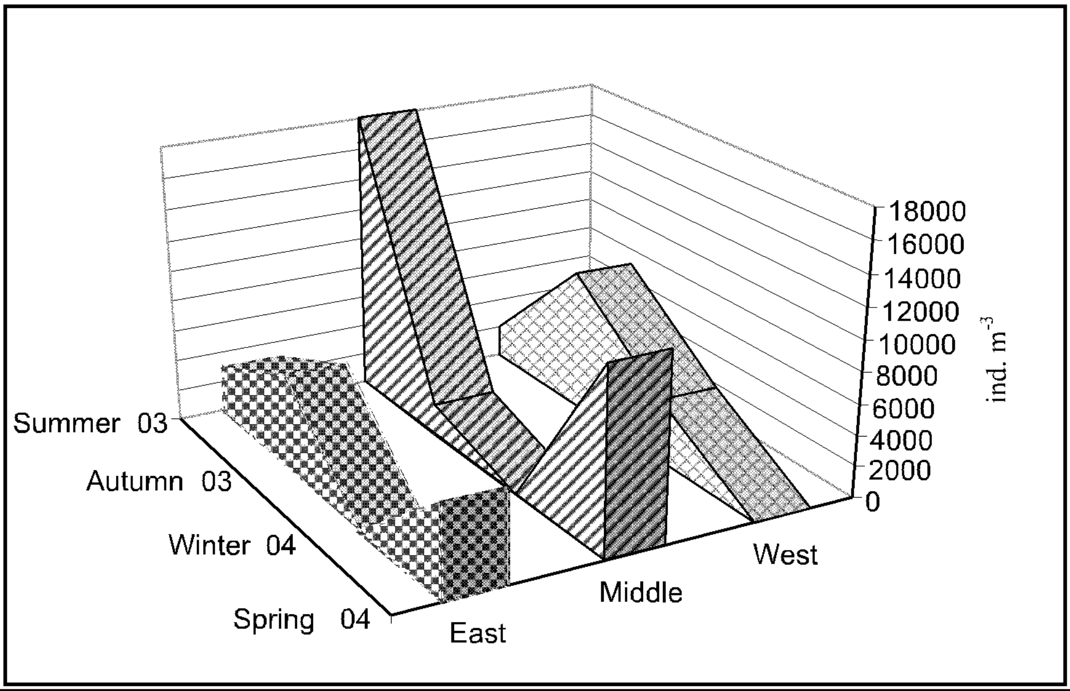


Fig. 7.9. **Standing crop of *Apocyclops panamensis* in Lake Burullus during 2003-2004 (after El-Shabrawy 2004).**

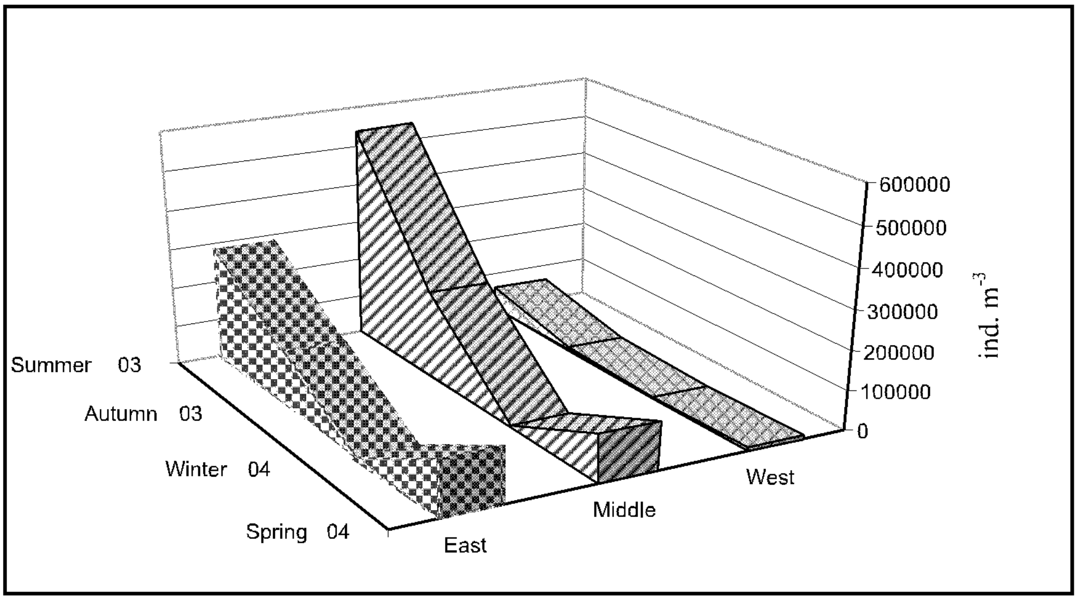


Fig. 7.10. **Standing crop of *Moina micrura* in Lake Burullus during 2003-2004.**

7.2.3.2. *Diaphanosoma mongolanium*

This species was found to be an aestival plankter, owing to its highest occurrence in summer (Fig. 7.11), where it attained a major peak of 45,000 ind.m^{-3} at the eastern sector of the lake. The population density of this species was sharply decreased during the other seasons, Robinson and Robinson (1971) mentioned that *D. mongolanium* was common throughout the hot period but was absent or rare from early December until late June in Lake Chad (El-Shabrawy 2004).

7.2.3.3. *Bosmina longirostris*

B. longirostris was highly represesnted at the western sector compared to other sectors of the lake (Fig. 7.12). It was the most abundant cladoceran species, that peaked in winter (El-Bassat 2002). Moreover, *B. longirostris* filters large algae (> 20 µm) at a faster rate than small cells, as a result of structure of its thoracic limbs.

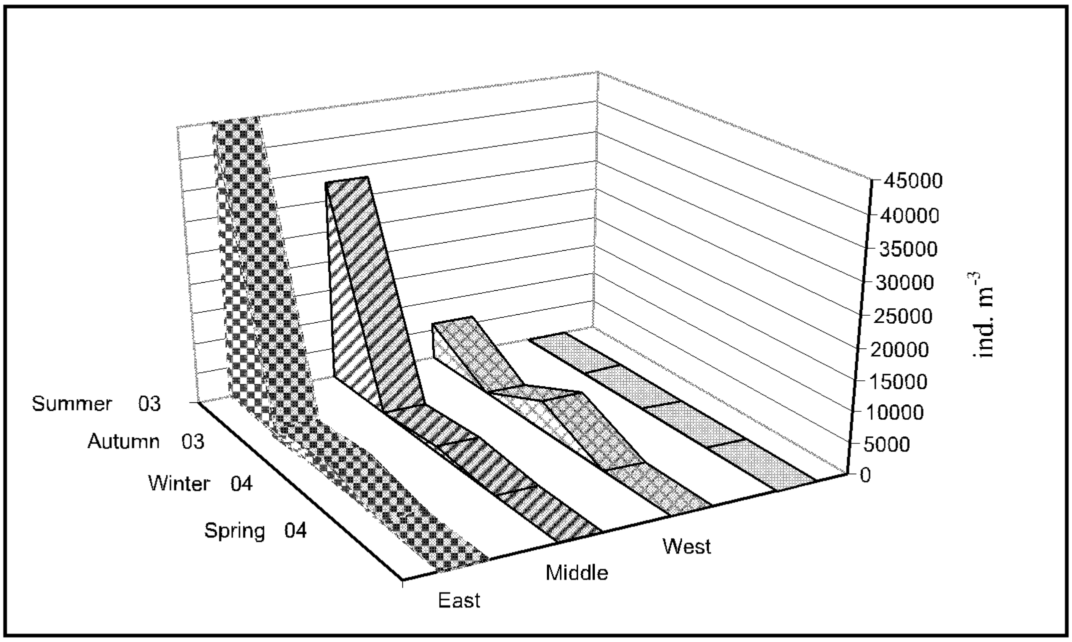


Fig. 7.11. **Standing crop of *Diaphanosoma mongolanium* in Lake Burullus during 2003-2004.**

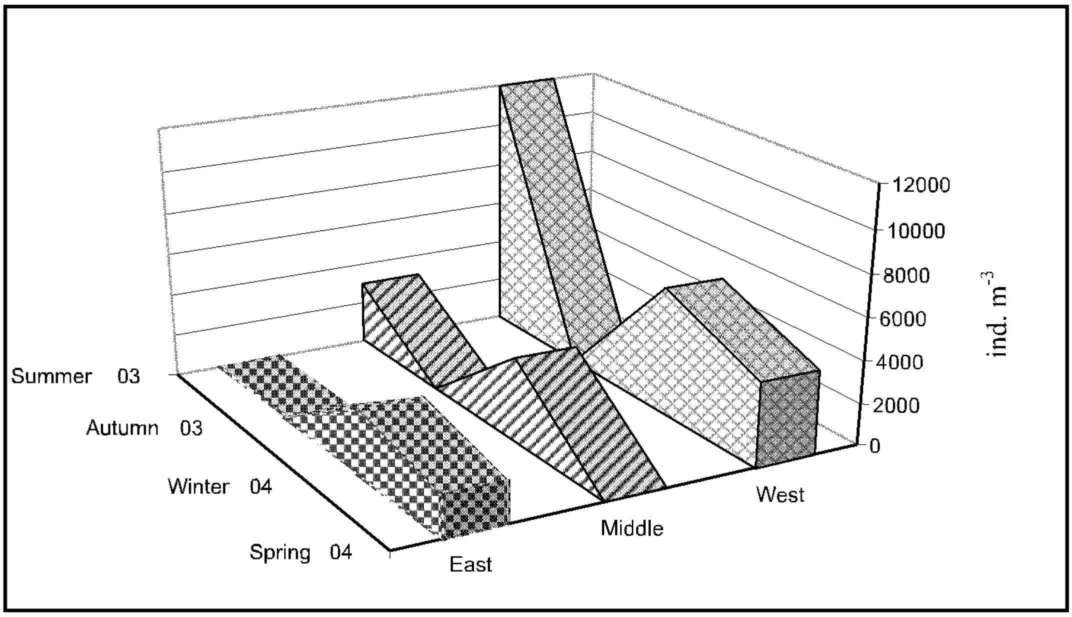


Fig. 7.12. **Standing crop of *Bosmina longirostris* in Lake Burullus during 2003-2004.**

7.3. POPULATION DYNAMICS OF ZOOPLANKTON

Seventy five species of zooplankton community were identified from Lake Burullus during the 2004 survey (El-Shabrawy 2004): 39 Rotifera, 15 Copepoda, 9 Cladocera, 8 Protozoa and 4 meroplankton species (Table 7.1). Generally, the population density of zooplankton is obviously high in the western sector of the lake, compared with the middle and eastern sectors (Fig. 7.13). Regarding seasonal variation, two population density peaks were observed in summer 2003 and winter 2004 (1599900 and 1709500 ind. m^{-3} respectively), while spring 2004 sustained the minimum population of 681300 ind. m^{-3}. As shown in Table (7.2), the standing crop of zooplankton was obviosly higher in 2001/02 and 2003/04 (666575 and 1193509 ind. m^{-3}) as compared with the situation in 1978 and 1987/88; 111000 and 183000 ind. m^{-3}, respectively (Aboul-Ezz 1984 &1995). The species composition of zooplankton community undergoes distinct changes throughout the seasons which can be easily observed in an eutrophic lake (Gliwicz 1977). Species or even genera reaching their maximum abundance in spring are replaced by others in summer.

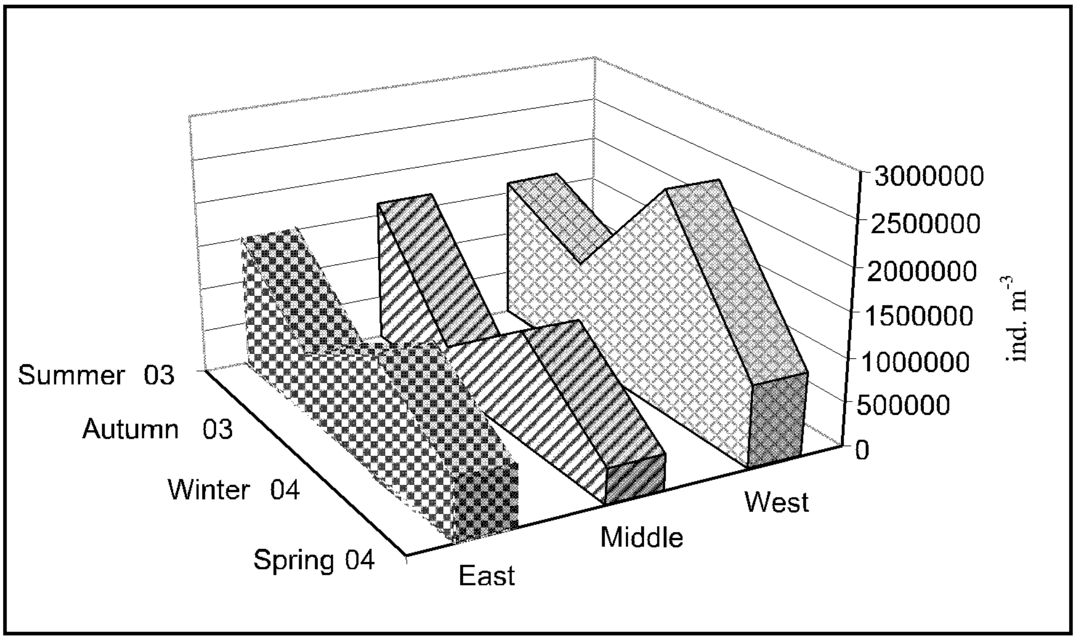


Fig. 7.13. **Standing crop of total zooplankton in Lake Burullus during 2003 – 2004.**

Rotifera is the most abundant group in all seasons and stations, comprising 66.3% and 76.7% of total zooplankton in 2001/02 and 2003/04, respectively (Table 7.2 and Fig. 7.14); while in 1978 and 1987/88 it was only forming 17% and 15.5 % of total zooplankton. They were represented by 34 and 39 species, which relatively higher than that recorded by Aboul-Ezz (1984 & 1995) in 1978 and 1987–1988 (27 and 26 species, respectively) (Table 7.3 and

Fig. 7.15). Rotifera exhibits more or less the same trend as the total zooplankton in its distribution and seasonal variation (Fig. 7.16). *Brachionus angularis, Brachionus calyciflorus, Brachionus urceolaris, Filinia longiseta, Keratella quadrata* and *Polyarthra vulgaris* were reported to be the most common species.

Table 7.2. **Standing crop of different zooplankton groups (ind. m^{-3}) and their percentage frequency to total zooplankton during 1978, 1987 / 1988 and 2003 / 2004.**

Group	Aboul-Ezz (1984)		Aboul-Ezz (1995)		El-Shabrawy (2002)		El-Shabrawy (2004)	
	1978		1987-1988		2001 – 2002		2003 - 2004	
	ind.m^{-3}	%	ind. m^{-3}	%	ind. m^{-3}	%	ind. m^{-3}	%
Rotifera	18902	17.0	28300	15.6	441905	66.3	915625	76.7
Copepoda	76135	68.4	67000	36.6	189905	28.5	110350	9.2
Cladocera	9808	8.8	40300	21.8	20902	3.1	145417	12.2
Others	6509	5.8	47500	26	13864	2.1	22117	1.9
Total	**111354**	**100**	**183100**	**100**	**666575**	**100.0**	**1193509**	**100.0**

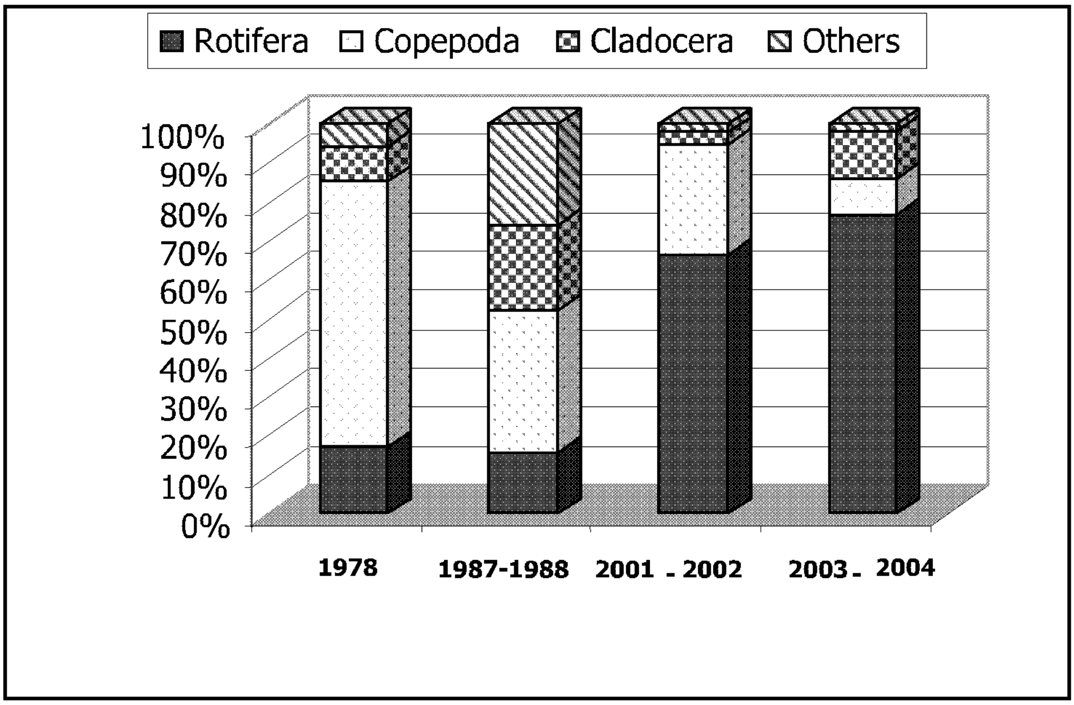


Fig. 7.14. **Percentage composition of zooplankton groups in Lake Burullus during different periods.**

Table 7.3. **Species diversity of zooplankton groups during different periods.**

Groups	Aboul-Ezz (1984)	Aboul-Ezz (1995)	El-Shabrawy (2002)	El-Shabrawy (2004)
	1978	**1987 - 1988**	**2001 - 2002**	**2003 - 2004**
Rotifera	27	26	34	39
Cladocera	9	7	7	9
Copepoda	44	26	7	15
Total	**80**	**59**	**48**	**63**

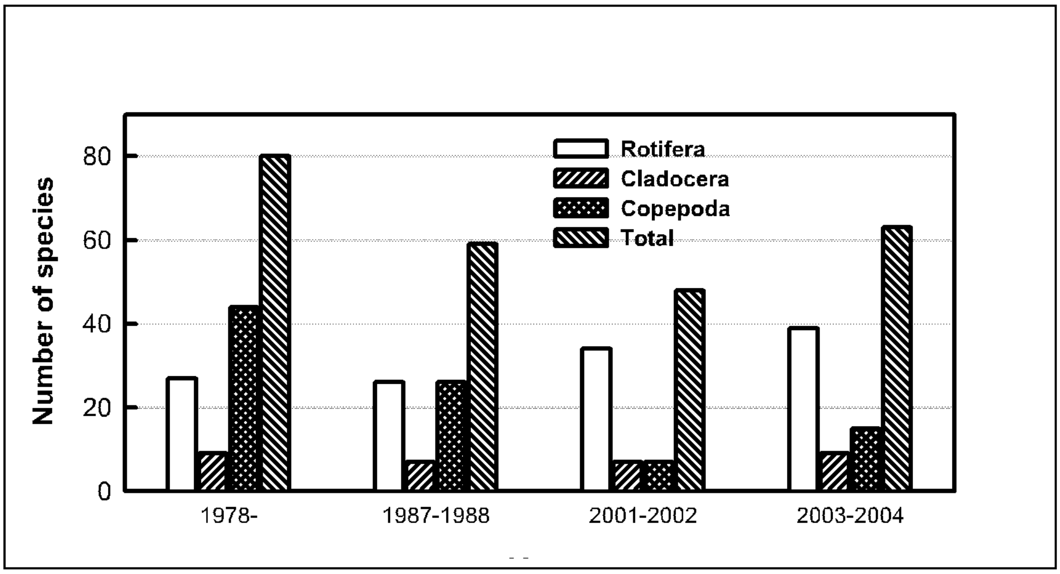


Fig. 7.15. **Species diversity of zooplankton groups in Lake Burullus during different periods.**

Copepoda was the second abundant and common group, forming 28.5 % of the total zooplankton density during 2001/02 and occupied the third position, contributing 9.2% of the total zooplankton crops in 2003/04. Seven and 15 copepod species were identified in Lake Burullus during 2001/02 and 2003-04, which are very low, compared with 44 and 26 species recorded by Aboul-Ezz (1984 & 1995, respectively) (Table 7.3). In fact, there are three reasons, among others, for such reduction: many records of copepods species were misidentified, as 9 species of *Cyclops* and 5 *Diaptomus* were only restricted to temperate region not sub-tropical region, where Lake Burullus lies; the disappearance of all marine copepod species; and the eutrophication process always accompanied with decreasing the diversity of species.

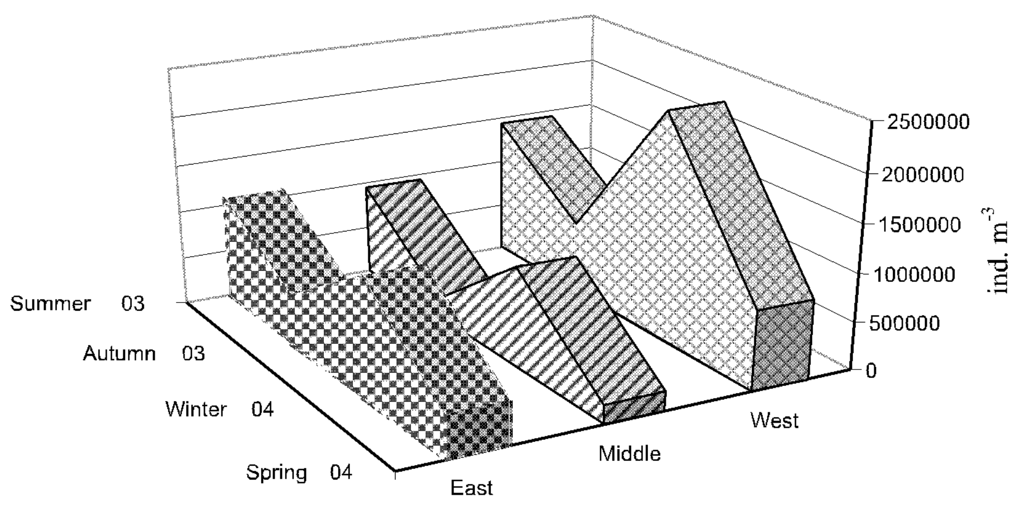


Fig. 7.16. **Standing crop of total Rotifera in Lake Burullus during 2003 – 2004.**

Regarding seasonal variation, the highest density of copepods occurred in western area of the lake in Autumn 2003 (371,000 ind. m^{-3}) (Fig. 7.17). Nauplius larvae dominated the copepodid and adult stages, contributing 62.2 and 51.6% of total copepods density in 2001-02 and 2003-04, respectively. Previous studies showed that Copepoda was the first predominant group, forming 68.4%, in 1978 decreased to 36.6% of total zooplankton in 1987–1988, respectively (Table 7.2).

Cladocera comes next, contributing 3.1% of the total zooplankton count in 2001-02 and increased to 12.2% in 2003-04. It was represented in the lake by 1 dominant, 1 sub-dominant, 2 rare and 5 very rare species. Contrary to the mentioned groups, the standing crop of Cladocera reached its maximum in summer with a major peak of 590,000 ind. m^{-3} at the middle area of the lake. It was faintly represented or even absent from most stations in winter (Fig. 7.18).

The percentage composition of Cladocera was obviously decreased from 8.8% and 21.8 % in 1979 and 1987/1988 to 3.1 % during 2001/02, then increased to 12.2% in 2003/04 (Table 7.2); while the diversity of species shows a slight decrease from 9 in 1978 to 7 during 2001/02. Nine species were recorded in 2003/04 (Table 7.1). *Moina micrura* and *Diaphanosoma mongolanium* were common species, while the rest of species were frequently encountered.

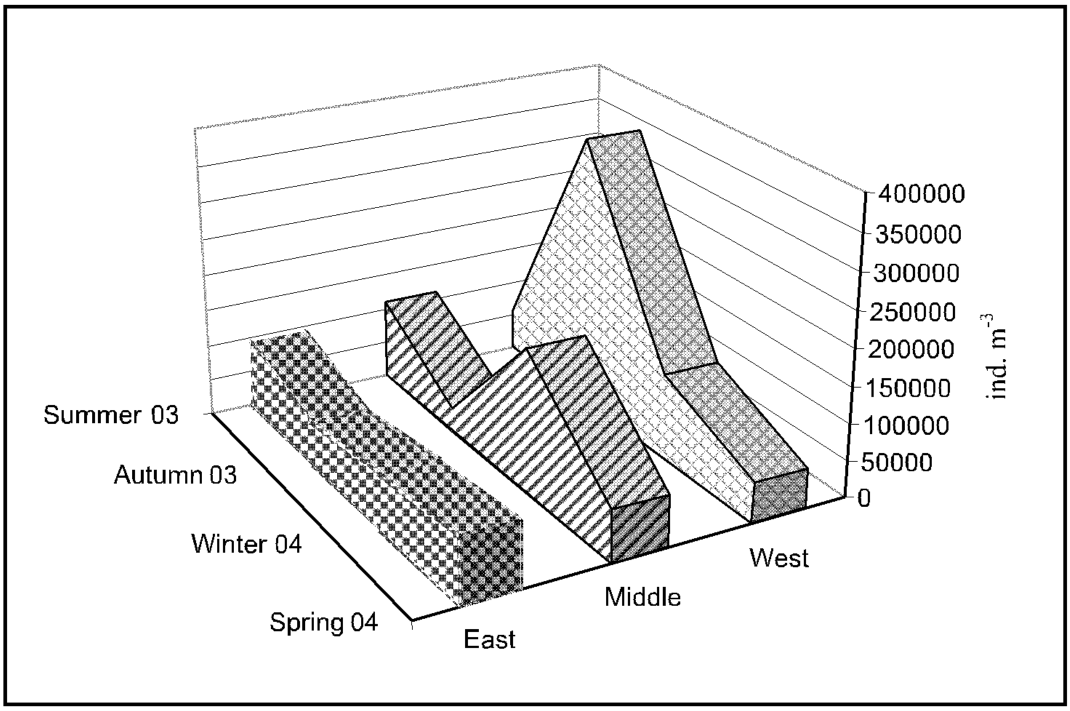


Fig. 7.17. **Standing crop of total Copepoda in Lake Burullus during 2003 – 2004.**

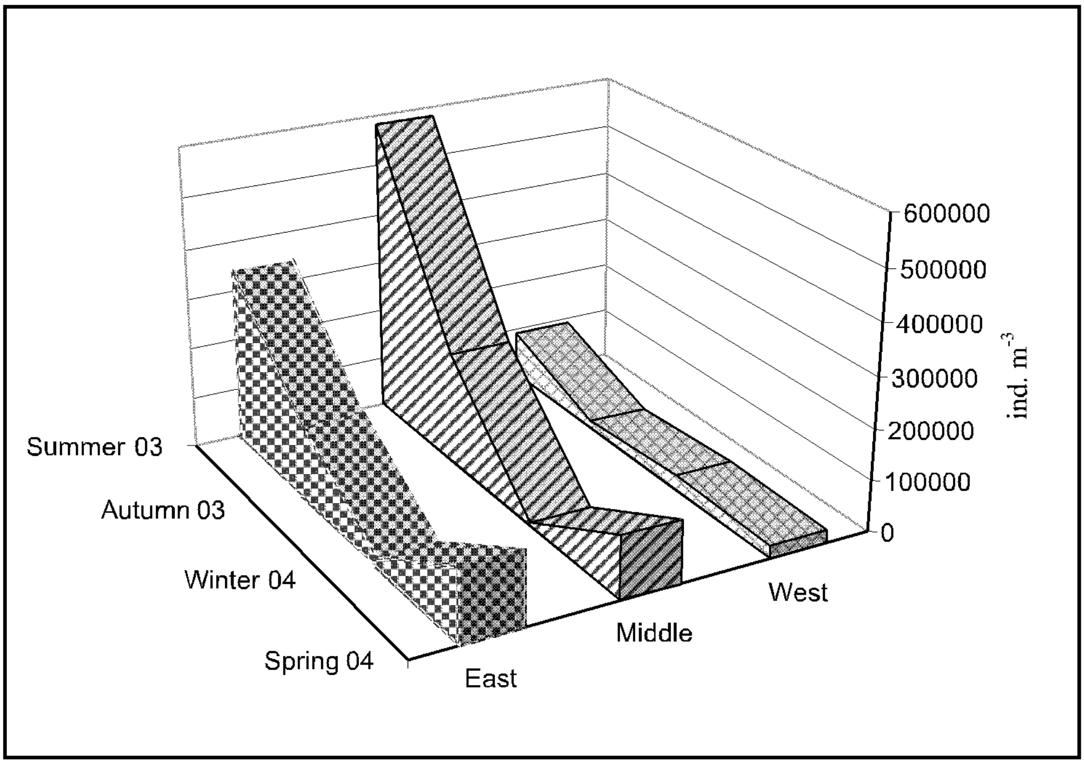


Fig. 7.18. **Standing crop of total Cladocera in Lake Burullus during 2003 – 2004**

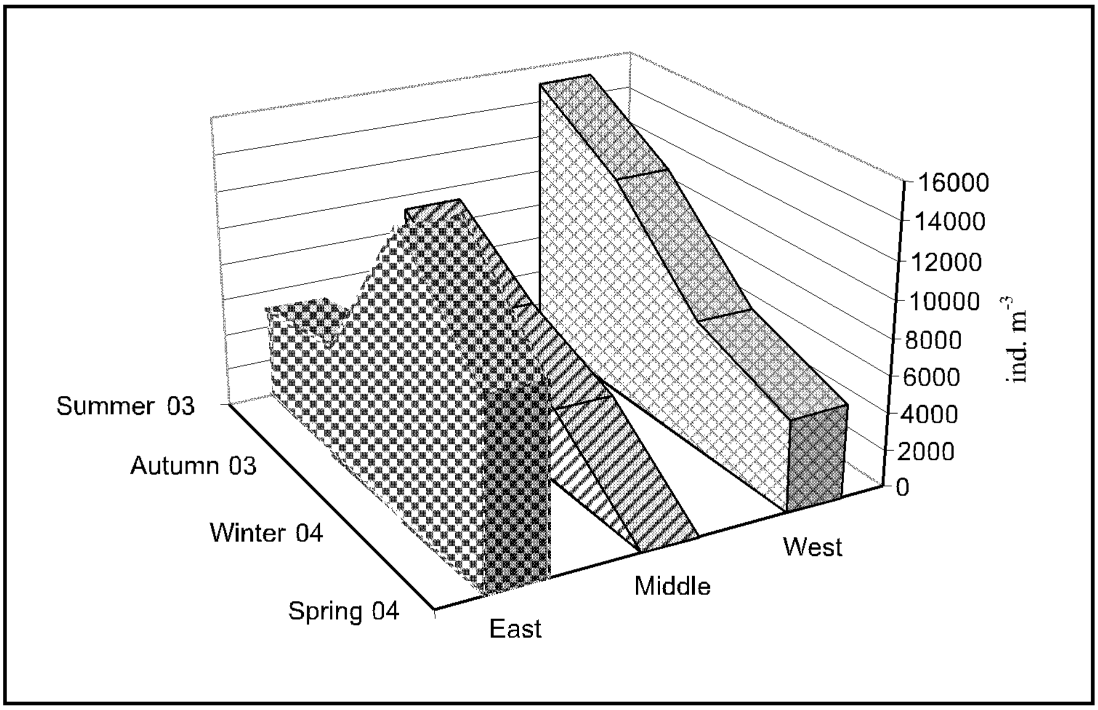


Fig. 7.19. **Standing crop of total meroplankton in Lake Burullus during 2003 – 2004.**

7.4. INDICATOR SPECIES

7.4.1. Eutrophication-indicator species

Zooplankton is a reliable indicator of changes in water quality, because it is strongly affected by environmental conditions and responds quickly to changes in water quality**.** Among zooplankton, rotifers with their high population turnover rates, are particularly sensitive to water quality changes. They are good indicators of saprobity (i.e. the content of putrescible organic matter), as expressed by BOD_5 (Sladecek 1983). Other studies have shown that eutrophication affects zooplankton composition, shifting the dominance from large species (Copepoda) to smaller ones (Rotifera) (Premazzi & Chiaudani 1992). Xenosaprobic and oligosaprobic rotifers are considered as indicators of oligotrophic conditions, while Beta and Alpha mesosaprobic as indicators of eutrophy.

The dominant rotifer genera and species in Lake Burullus (*Keratella* spp., *Brachionus* spp., *Polyarthra vulgaris, Filina longiseta* and *Synchaeta oblonga*) are eutrophic indicator species, classified by Saldecek (1983) as Alpha and Beta mesosaprobic. Thus, the community composition of the rotifers and their significant dominance over the other zooplankton groups indicate that Lake

Burullus is a highly eutrophic ecosystem and shows slight signs of partial organic pollution. Such eutrophication appears to be more related to the increased fertility of water due to the high concentration of nutrients inputs to the lake via agricultural drains.

The genus *Brachionus* is the most predominant and common rotiferan plankter in the lake and is represented by 9 species. Angeli (1976) stated that the simultaneous presence of several species of the genus *Brachionus* was a good indication of the eutrophic nature of an aquatic ecosystem. Sladecek (1983) established a *Brachionus* : *Trichocerca* quotient (QB/T):

QB/T = No. of species of *Brachionus* / No. of species of *Trichocerca*

Values of QB/T less than 1.0 mean oligotrophic condition, values between 1.0 and 2.0 mean mesotrophy and values over 2.0 mean eutrophic condition. When we applied this quotient in Lake Burullus, QB/T = 9/4 = 2.5, so the lake is eutrophic ecosystem. The annual fish yield revealed a gradual increase from 7018 ton in 1979 to 22510 ton in 1987 and reached maximum of 55000 ton in 1999. This is concurrent with the population density of phytoplankton and zooplankton, which gives another indication for the gradual increase of lake eutrophication (Fig. 7.20). Pejler and Berzins (1994) listed many species that indicate organic pollution, of them, many species have been recorded in Lake Burulls such as *Brachionus claciflorus, B. urceolaris, Polyarthra vulgaris, Filinia longiseta* and *Synchaeta oblonga.*

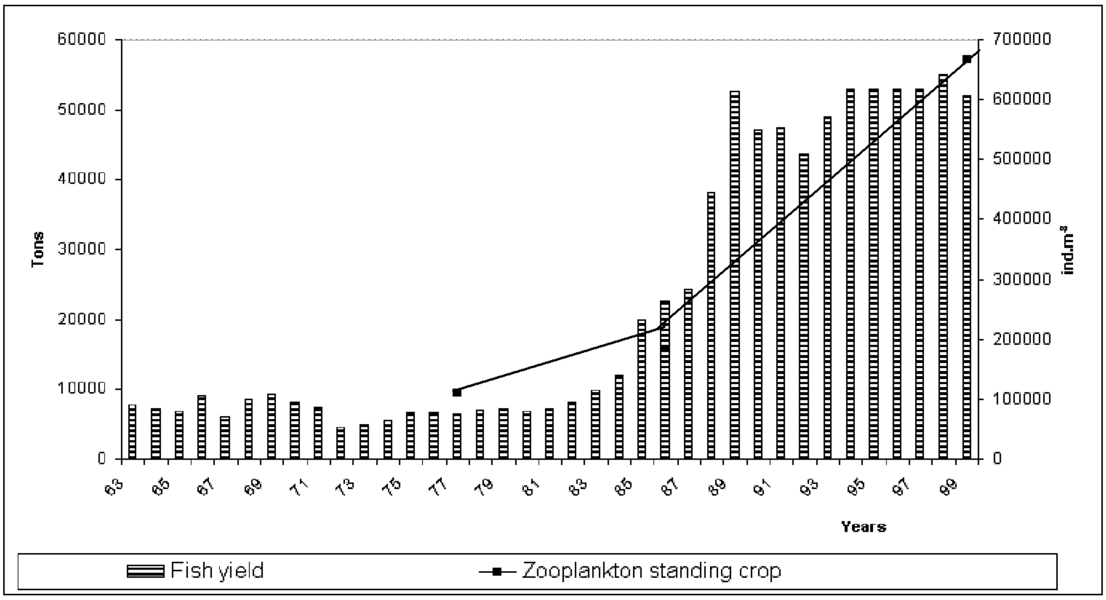


Fig.7.20. **Fish yield and zooplankton standing crop in Lake Burullus during different time intervals.**

7.4.2. Salinity-indicator species

The hydrographic condition of Lake Burullus has been changed since few years ago, (i.e. the amount of drainage fresh water was increased and led to decrease in salinity of the lake water). The disappearance of marine species, previously recorded by Aboul-Ezz (1984 & 1995), confirmed this phenomenon. These species are: *Oithona nana*, *Oithona helgolandica*, *Oithona robusta*, *Macrosetella gracilis*, *Canvella perplexa*, *Euterpina acutifrons*, *Isias clavipes*, *Paracalanus parvus*, *Calanus brevicornis*, *Centropages* sp., *Sagitta* sp., *Oikopleura dioica* and *Fritillararia borealis*. Increasing predominance of freshwater components in the fish stock of the lake and decreasing marine fishes (Khalil and El –Dawy 2002) are another sign for decreasing salinity.

7.5. ZOOPLANKTON AND GUT CONTENTS OF FISHES:

El-Shabrawy (2004) studied the gut contents of Nile tilapia and mullets to investigate the importance of zooplankton for different fish species in the Lake .

7.5.1. *Oreochromis niloticus*

Zooplankton was infrequently found, contributing 13-18% of the total food except in winter, when it was highly detected, forming 45% of total food items (Fig 7.21). *Keratella quadrata* monopolized the other species.

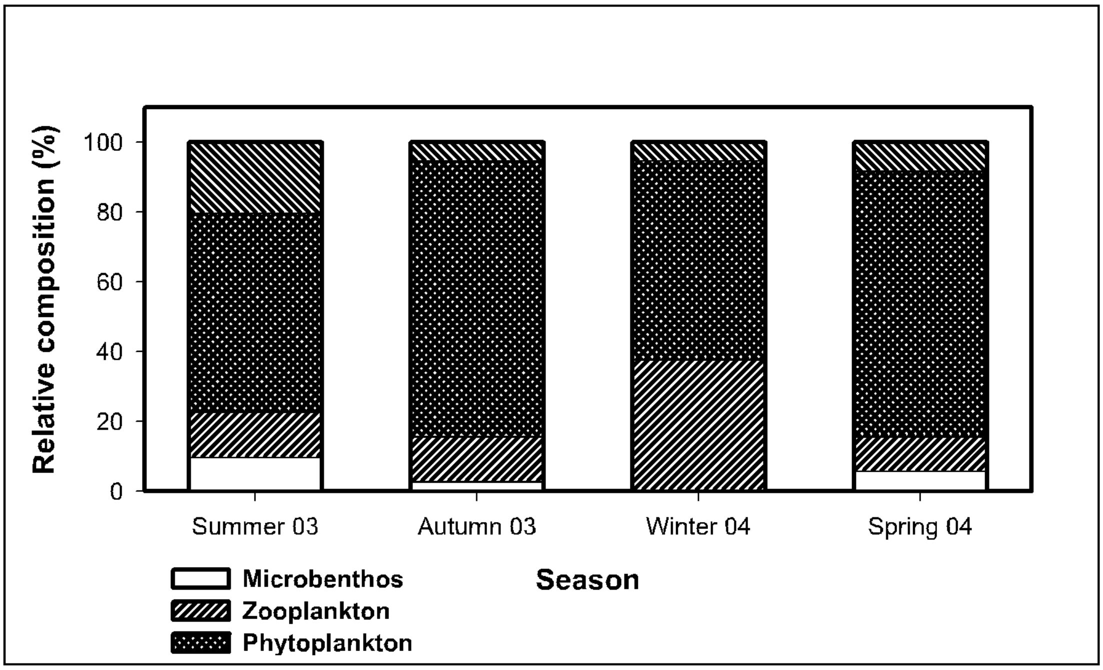


Fig 7.21. **Relative composition of different food items (%) in *Oreochromis niloticus* gut.**

7.5.2. Mullets

Mullets feed mainly on phytoplankton in winter, forming about 64.1% of total food items and was represented in the gut of all the studied fish species (Fig. 7.22). Bacillariophyceae was the most common group, forming 36% of total food and represented in 100% of the studied fish species (Fig 7.22). *Cyclotella* sp. was the most important food item, forming 23.3% of the total gut contents. Chlorophyceae, Cyanophyceae and Dinophyceae were contributing 14.5, 7.0 and 60.5%, respectively. Zooplankton contributed 32.5 % of the food items during winter. *Keratella quadrata* seems to be the most important food item, forming 21.3% of total gut contents. *Brachionus angularis* and *acanthocyclops americanus* were infrequently detected.

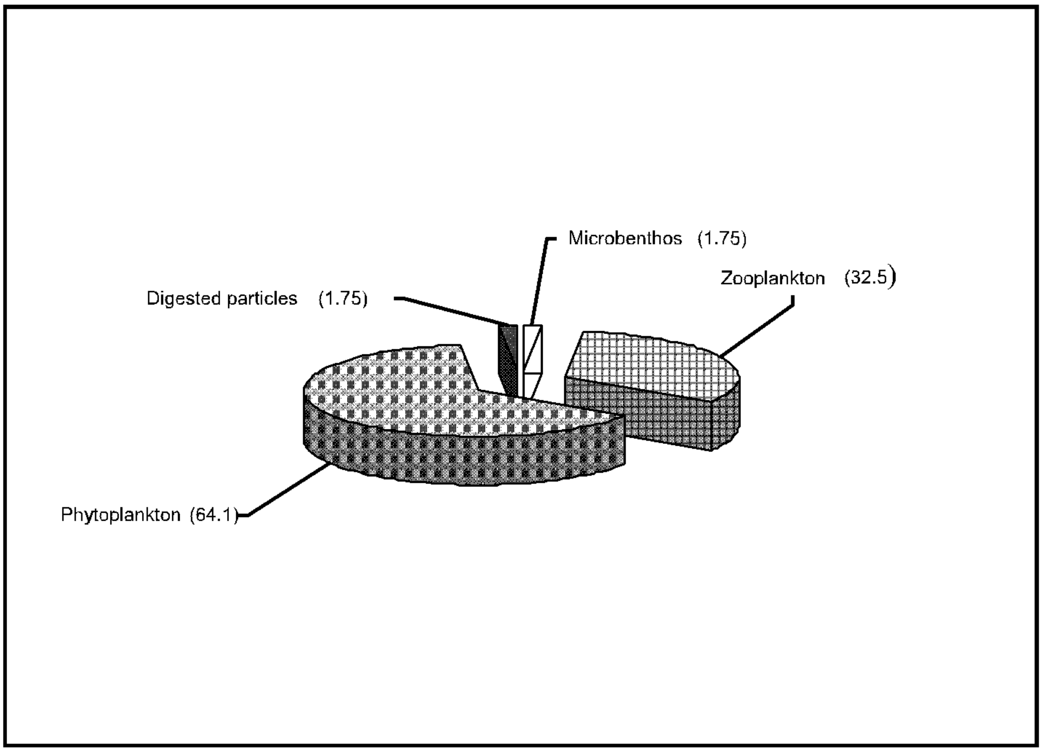


Fig 7.22. **Relative composition (%) of different food items in mullets (El-Shabrawy 2004).**

7.6. SUMMARY

Lake Burullus has become more eutrophic and productive ecosystem during the last decade, due to the increasing amount of discharged drainage water, loaded with nutrients into the lake via the southern drains. At the same time, diversity of zooplankton species was sharply decreased, due to disappearance of marine species as a result of salinity decreasing and increasing of organic pollution.

During 2001/02, 48 zooplankton species belonging to 3 main groups (34 Rotifera, 7 Copepoda and 7 Cladocera) were recorded in Lake Burullus. There was no sign of the occurrence of all marine species (13 species) which have been previously recorded during the seventies of the last century. 18 zooplankton species (freshwater in origin) were recorded for the first time in the Lake during a recent survey in 2003/04. During this survey, 75 species of zooplankton were identified from the Lake; 39 rotiferan species, 15 copepods, 9 cladocerans, 8 protozoans and 4 meroplankton species.

Some marine species [(*Oithona nana. Paracalanus parvus, Euterpina acutifrons, Harpacticus* sp. and *Macrosrtella gracillis* (Copepoda) and *Eutintinnus lusus-undae, Metacylis mediterrnean* (Protozoa)] started to re-occur in the lake at the area near El-Boughaz, particularly during spring 2004. This was mainly due to the construction of two radial canals and clearing of El-Boughaz canal.

In general, the population density of zooplankton was obviously high in the western sector compared with the middle and eastern sectors. Regarding seasonal variation, there was a gradual increase in zooplankton standing crop from a minimum of 437,000 ind. m^{-3} in summer until reaching a maximum of 1,174,000 ind. m^{-3} in spring 2002, with an annual average of 667,000 ind. m^{-3}. The present standing crop of zooplankton is 6 times higher as compared with the situation in the seventies.

Rotifera is the most abundant group in all seasons and areas of the Lake, comprising 66.3% and 76.7% of total zooplankton in 2001/02 and 2003/04; while in 1978 and 1987/88 it was forming only 17% and 15.5 % of the total zooplankton, respectively. Copepoda was the second abundant group, forming 28.5 % of the total zooplankton density during 2001/02 and occupied the third position, contributing 9.2% of the total zooplankton crops in 2003/04.

Gut content analysis of adult fishes inhabiting lake Burullus revealed that Tilapia and mullets mainly feed on *Keratella quadrata* (zooplankton) and *Cyclotella* sp. (phytoplankton), so mass culture of these two species are highly recommended when establishing fish hatchery for the lake.

7.7. REFERENCES

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7.8. PLATES OF ZOOPLANKTON OF LAKE BURULLUS (7.1-7.16)

(after Guerguess 1986 and 1993; El-Shabrawy 2004)

Plate 7.1
Brachionus angularis
Brachionus caudatus
Brachionus calyciflorus
Brachionus falcutus
Polyarthra vulgaris
Hexarthra oxuris
Asplachnia sieboldi
Anuraeopsis fissa

Plates 7.2
Keratella cochlearis
Keratella tropica
Keratella quadrata dispersa
Keratella quadrata quadrata
Proalides sp.
Lecane luna
Filinia longiseta
Brachionus urceolaris

Plates 7.3
Moina micrura
Diaphanosoma exesium
Bosmina longirostris

Plates 7.4
Macrothrix laticorinis

Plates 7.5
Thermocyclops neglectus

Plates 7.6
Acanthocyclops americanus

Plates 7.7
Anuraeopsis fissa
Brachionus calyciflorus
Brachionus caudatus
Brachionus falcatus
Brachionus plicatilis
Keratella cochlearis
Keratella tropica

Plates 7.8
Asplanchna sieboldi
Asplanchna priodonta
Proalids sp.
Trichocerca pusilla
Polyarthra vulgaris
Filinia longiseta

Plates 7.9
Lepadella ovalis
Lepadella patella
Colurella Adriatic
Lecane luna
Lecane arcula
Lecane depressa
Synchaeta oblonga
Hexartha oxyuris
Keratella quadrata

Plates 7.10
Diaphanosoma excisum
Moina micrura
Ceriodaphnia reticulata
Alonna intermedia
Chydorud sphaericus
Bosmina longirostris

Plates 7.11
Diaphanosoma mongolanoum
Macrothris laticornis

Plates 7.12
Nitocro lacustris
Onychocamptus mohamed

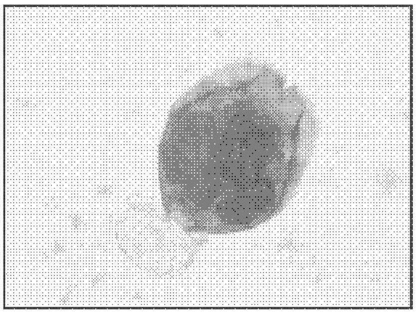
Plates 7.13
Thermocyclops crassus
Halicyclops magniceps

Plates 7.14
Mesocyclops leuckarti
Diacyclops bicuspidatus

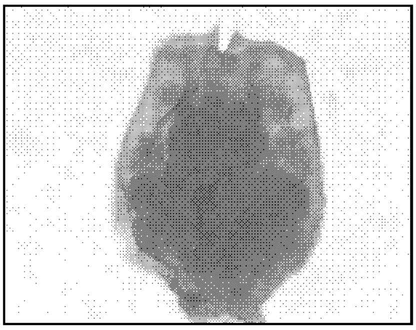
Plates 7.15
Acanthocyclops americanus

Plates 7.16
Ergasilus sieboldi
Acartia latisetosa
Canuella perplexa

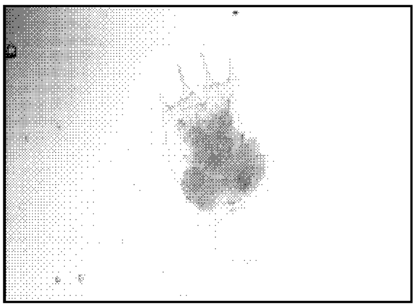
Plate 7.1



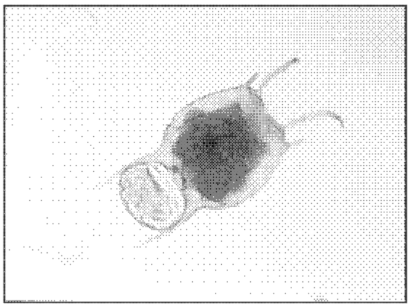
Brachionus angularis



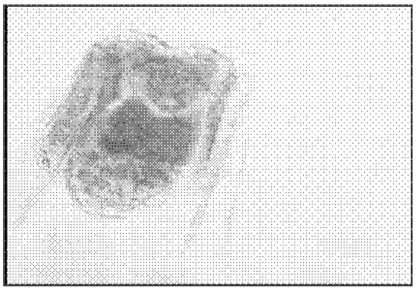
Brachionus caudatus



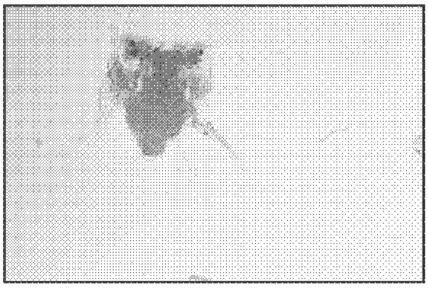
Brachionus calyciflorus



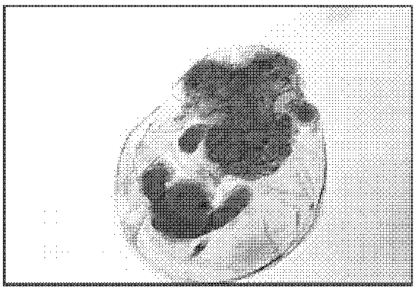
Brachionus falcatus



Polyarthra vulgaris



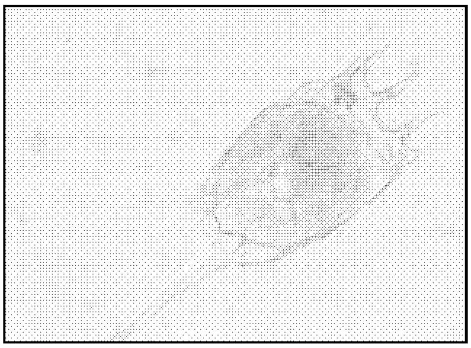
Hexarthra oxuris



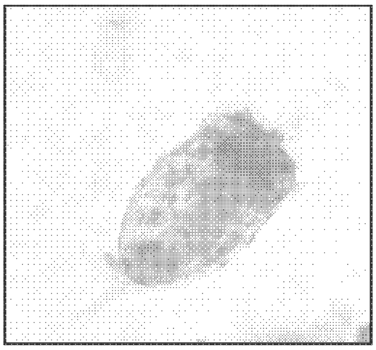
Asplachnia sieboldi

Anuraeopsis fissa

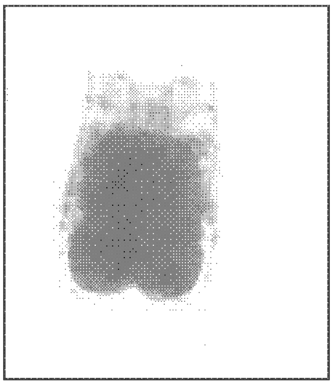
Plate 7.2



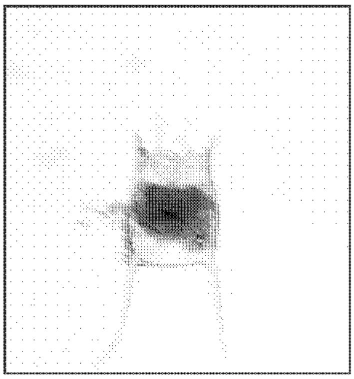
Keratella tropica



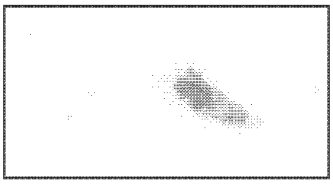
Keratella cochlearis



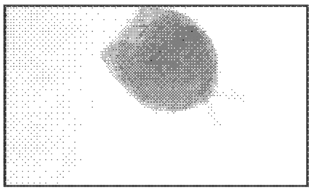
Keratella quadrata dispersa



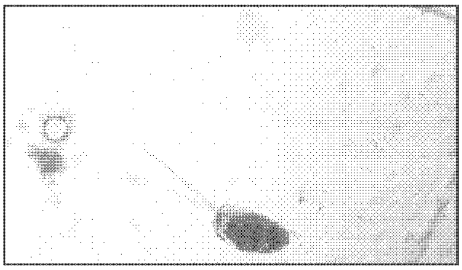
Keratella quadrata quadrata



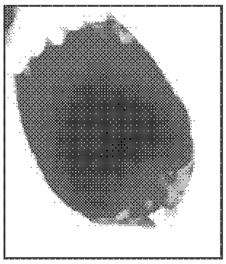
Proalides sp.



Lecane luna

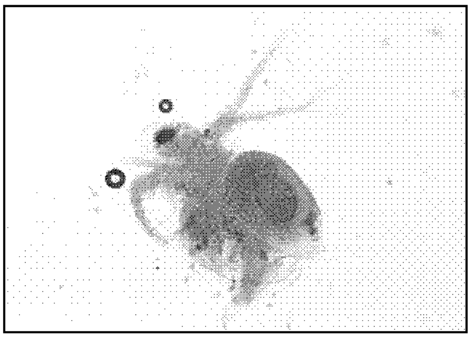


Filinia longiseta

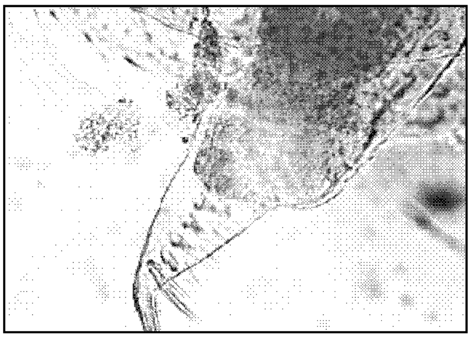


Brachionus urceolaris

Plate 7.3

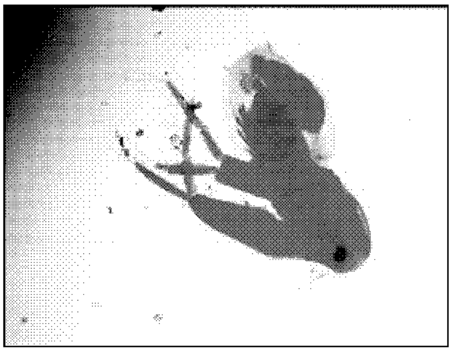


Adult female

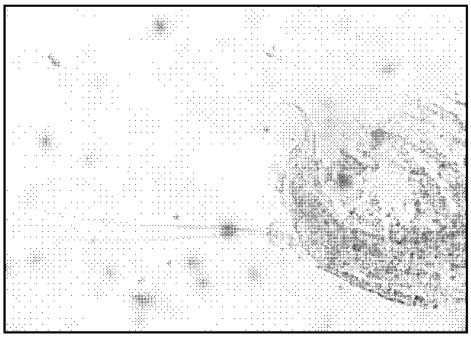


Postabdomen

Moina micrura

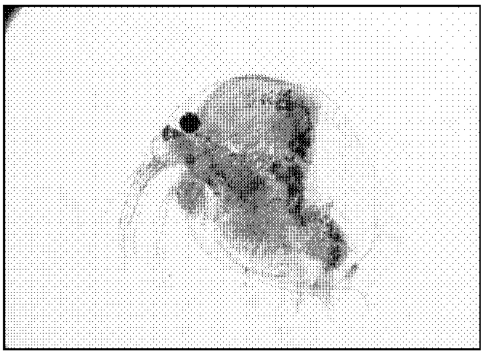


Adult female

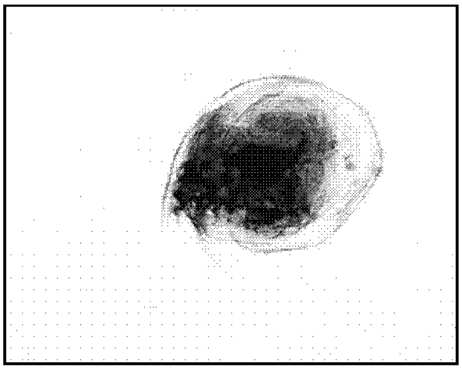


Postabdomen

Diaphanosoma exesium

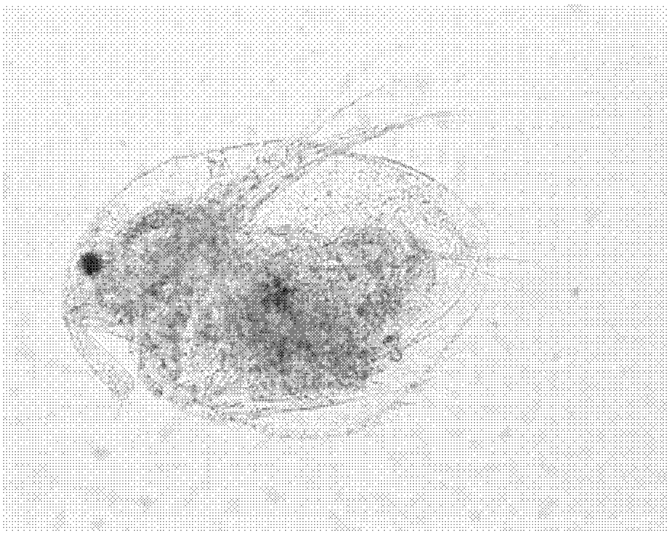


Bosmina longirostris

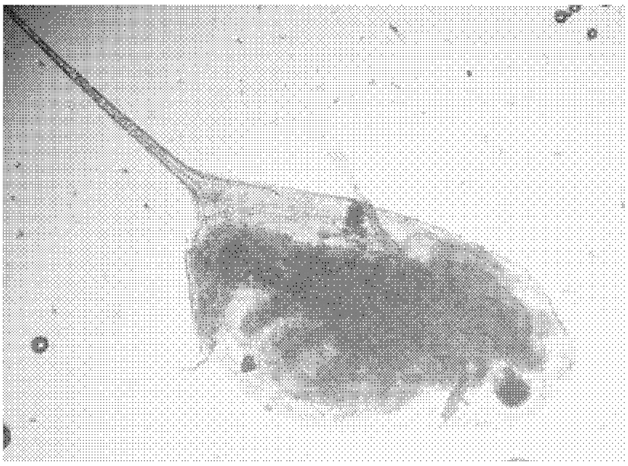


Chydorus sphearicus

Plate 7.4



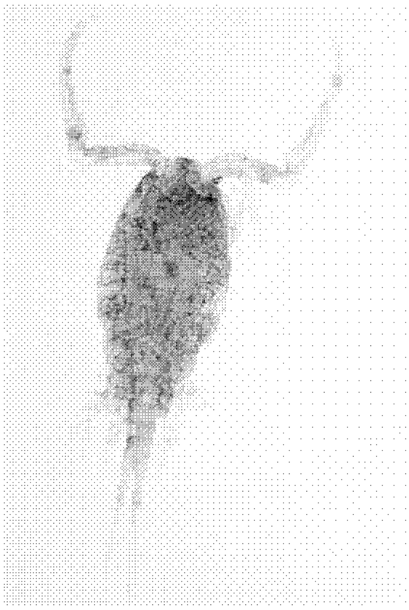
Macrothrix laticorinis



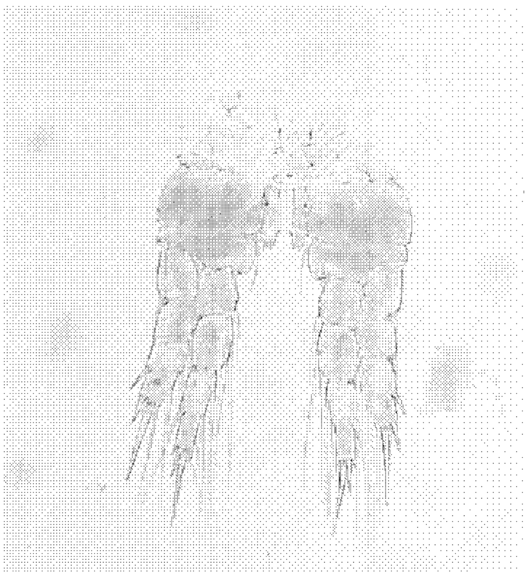
Daphnia similis

Plate 7.5

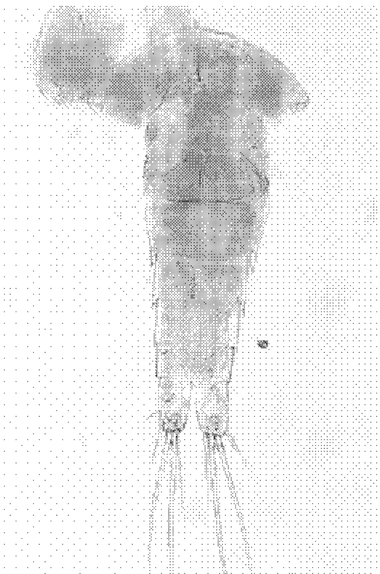
Adult female



Male



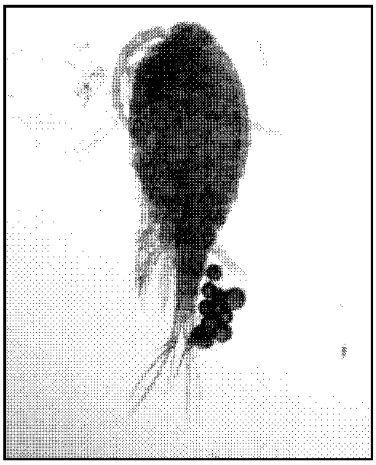
P4



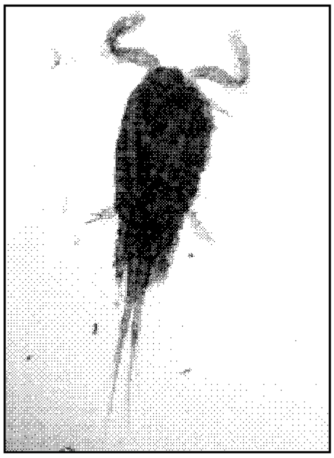
Postabdomen

Thermocyclops neglectus

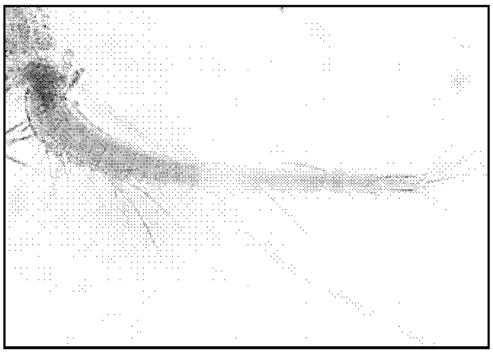
Plate 7.6



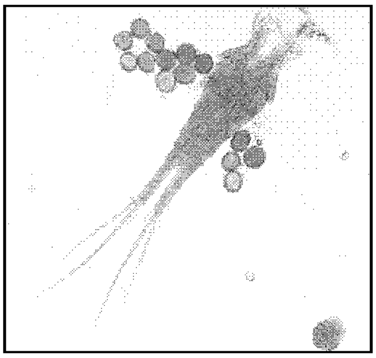
Female



Male



Antennae



Postabdomen

P4

Acanthocyclops americanus

Plate 7.7

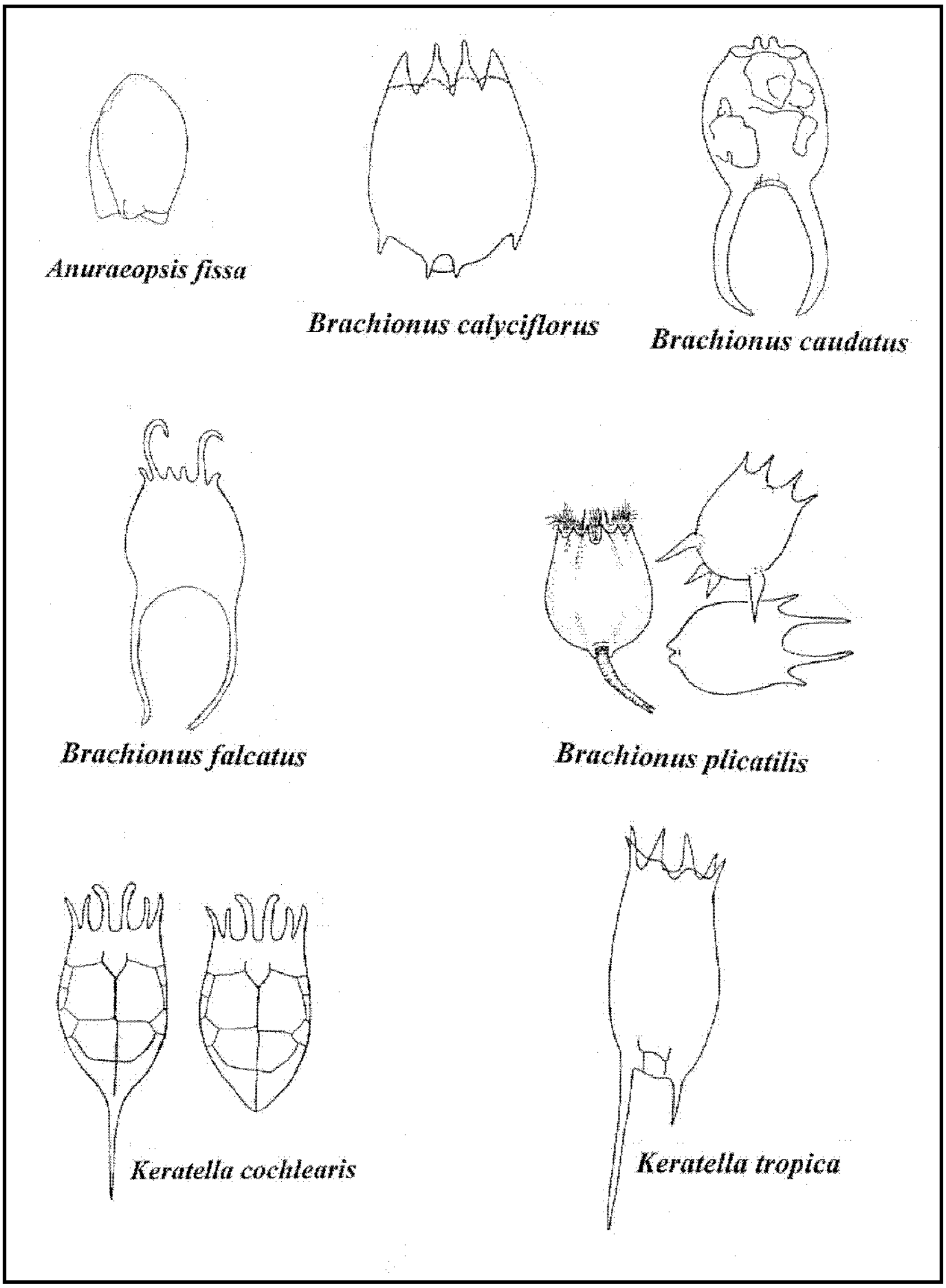

Anuraeopsis fissa
Brachionus calyciflorus
Brachionus caudatus
Brachionus falcatus
Brachionus plicatilis
Keratella cochlearis
Keratella tropica

Plate 7.8

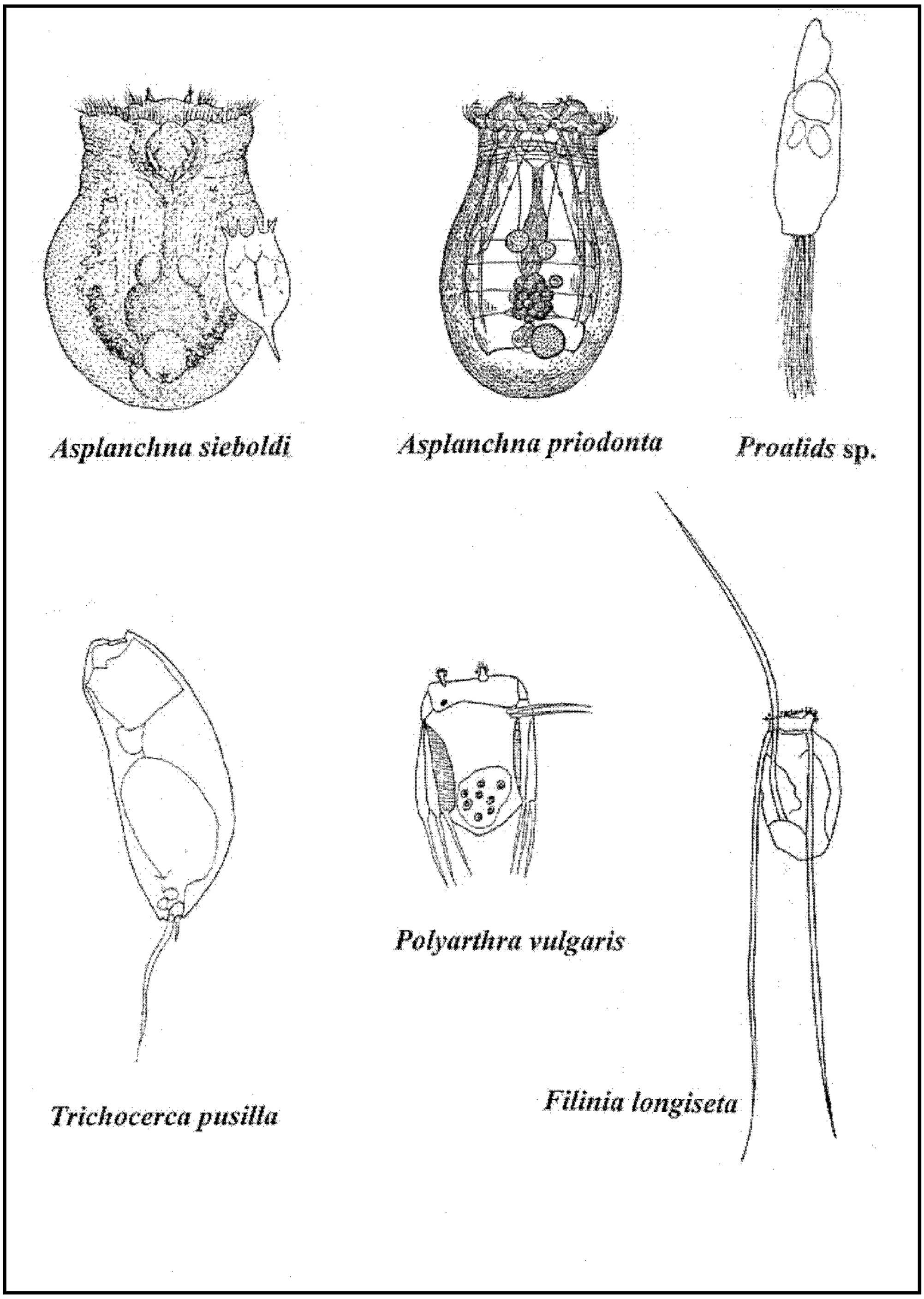

Asplanchna sieboldi
Asplanchna priodonta
Proalids sp.
Trichocerca pusilla
Polyarthra vulgaris
Filinia longiseta

Plate 7.9

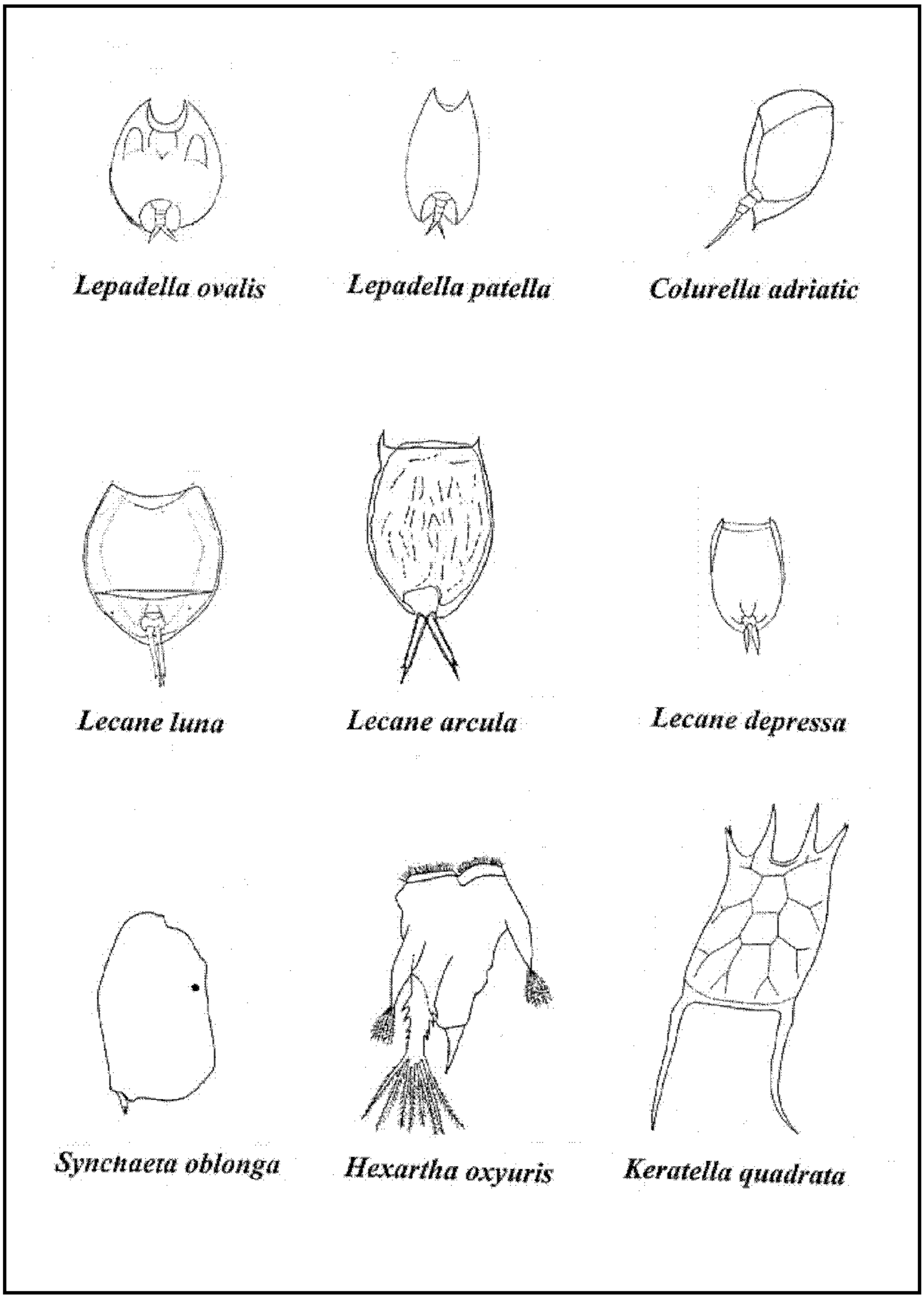
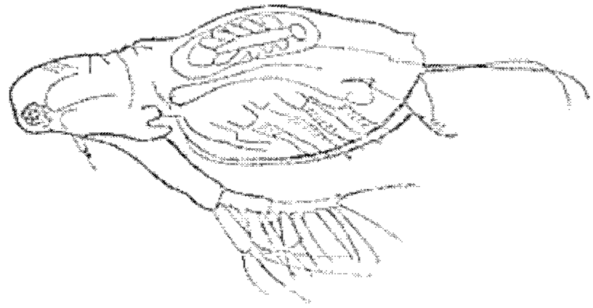
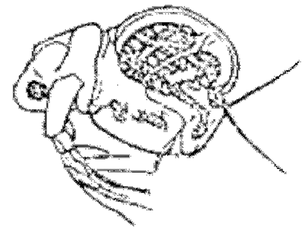

Lepadella ovalis
Lepadella patella
Colurella adriatic
Lecane luna
Lecane arcula
Lecane depressa
Synchaeta oblonga
Hexartha oxyuris
Keratella quadrata

Plate 7.10

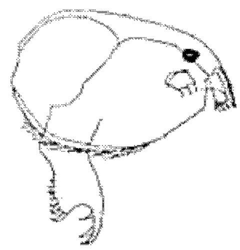


Diaphanosoma excisum

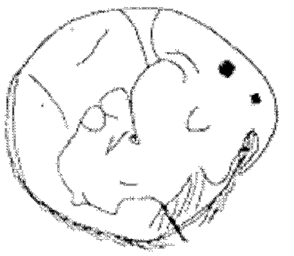


Moina micrura

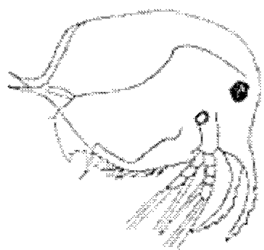
Ceriodaphnia reticulata



Alonna intermedia

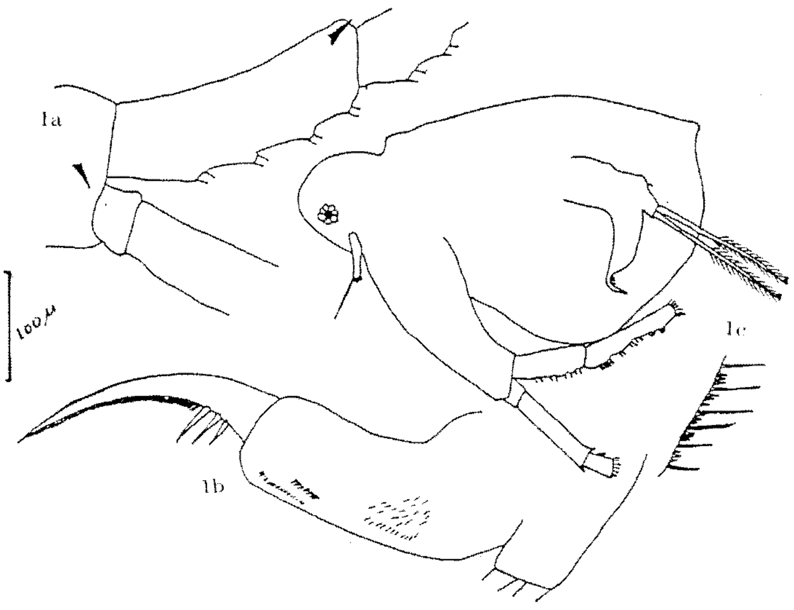


Chydorud sphaericus

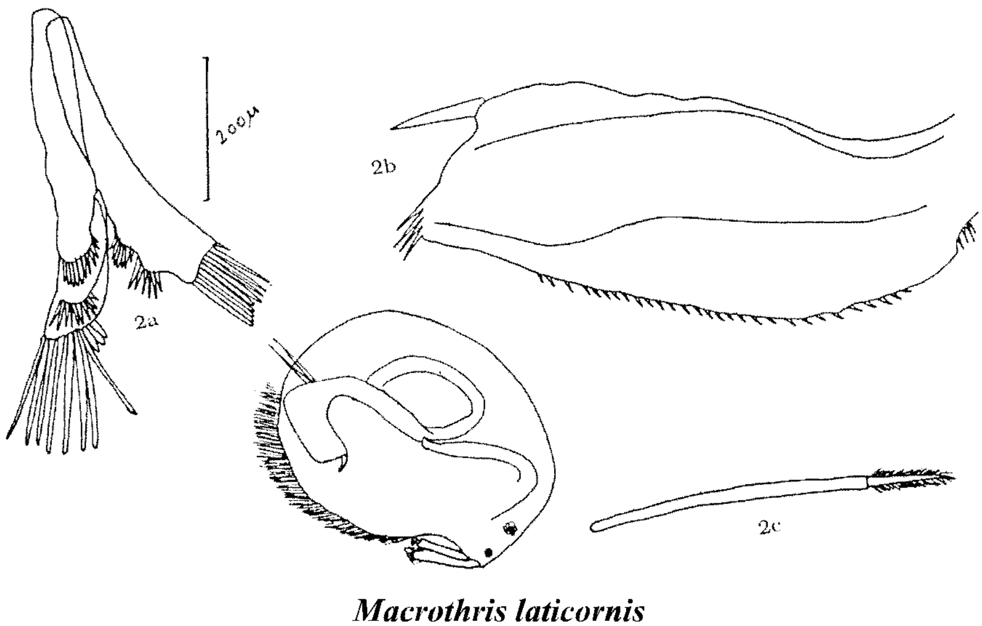


Bosmina longirostris

Plate 7.11

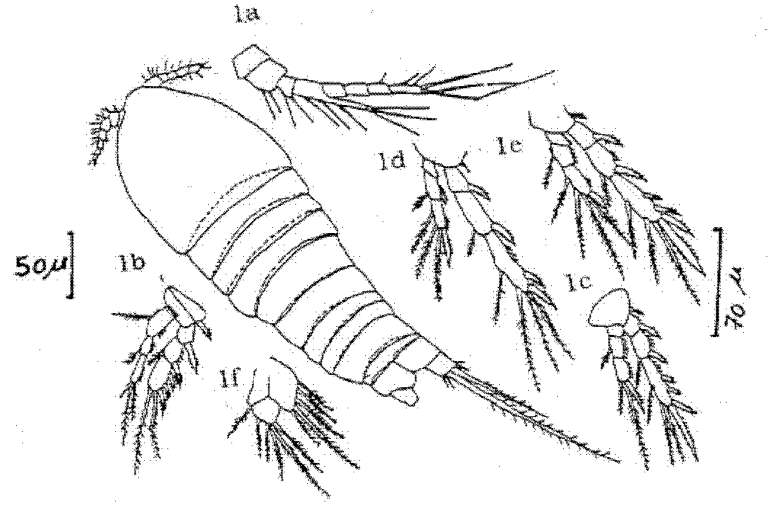


Diaphanosoma mongolanium
1a: second antennae, 1b: post abdomen, 1c: ventral shell margin

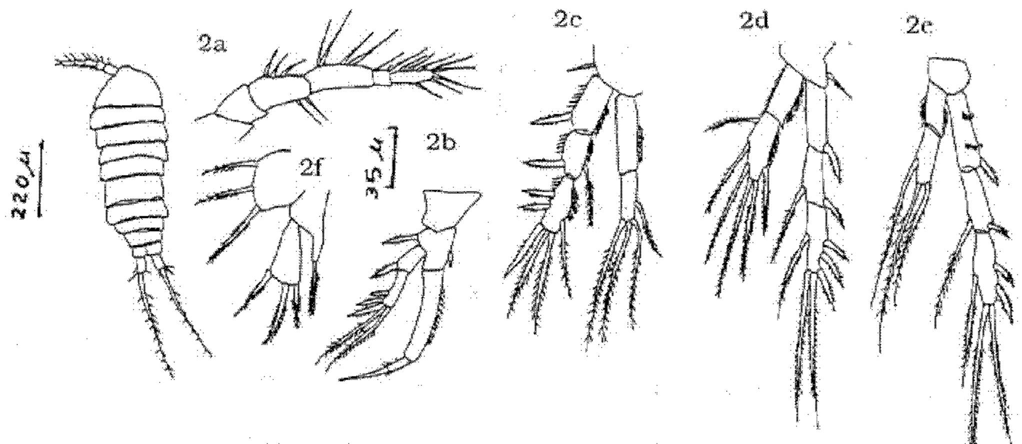


Macrothris laticornis
2a: first antennae, 2b: post abdomen, 2c: natatory setaae

Plate 7.12

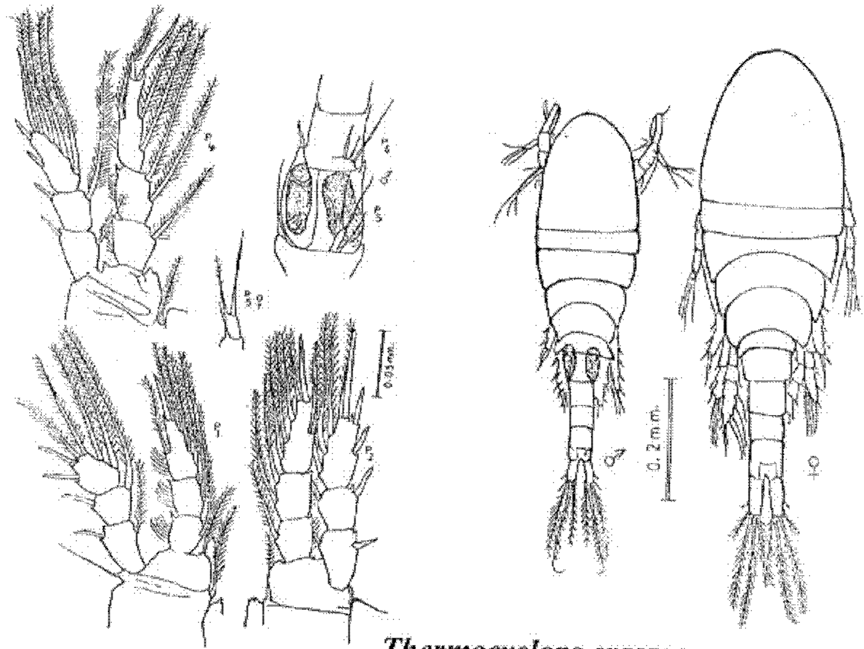


Nitocra lacustris
1a: A2, 1b: p1, 1c: p2, 1d: p3, le:p4, 1f: p5

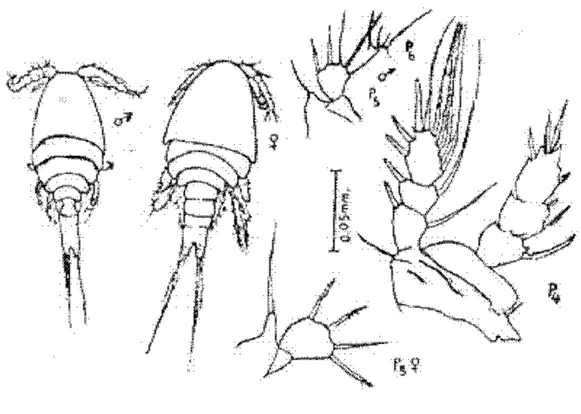


Onychocamptus mohamed
2a:A2, 2b:p1, 2c:p2, 2d:p3, 2e:p4, 2f:p5

Plate 7.13

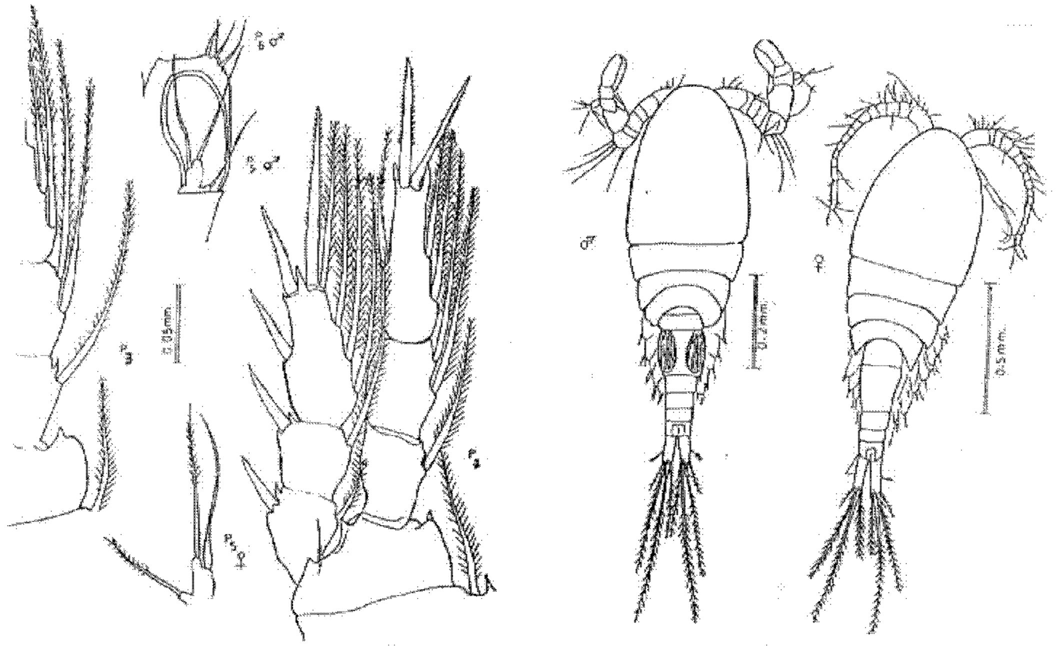


Thermocyclops crassus

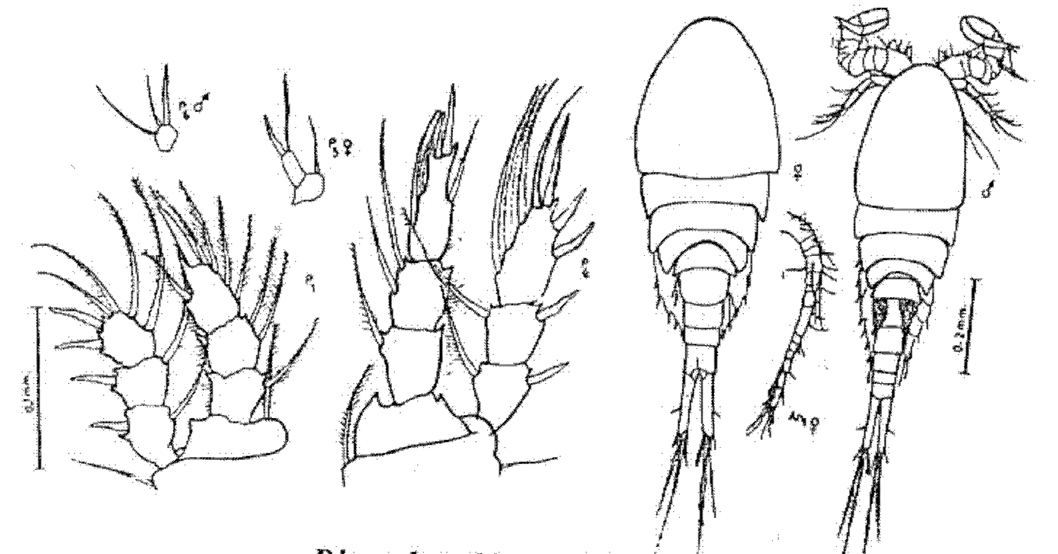


Halicyclops magniceps

Plate 7.14

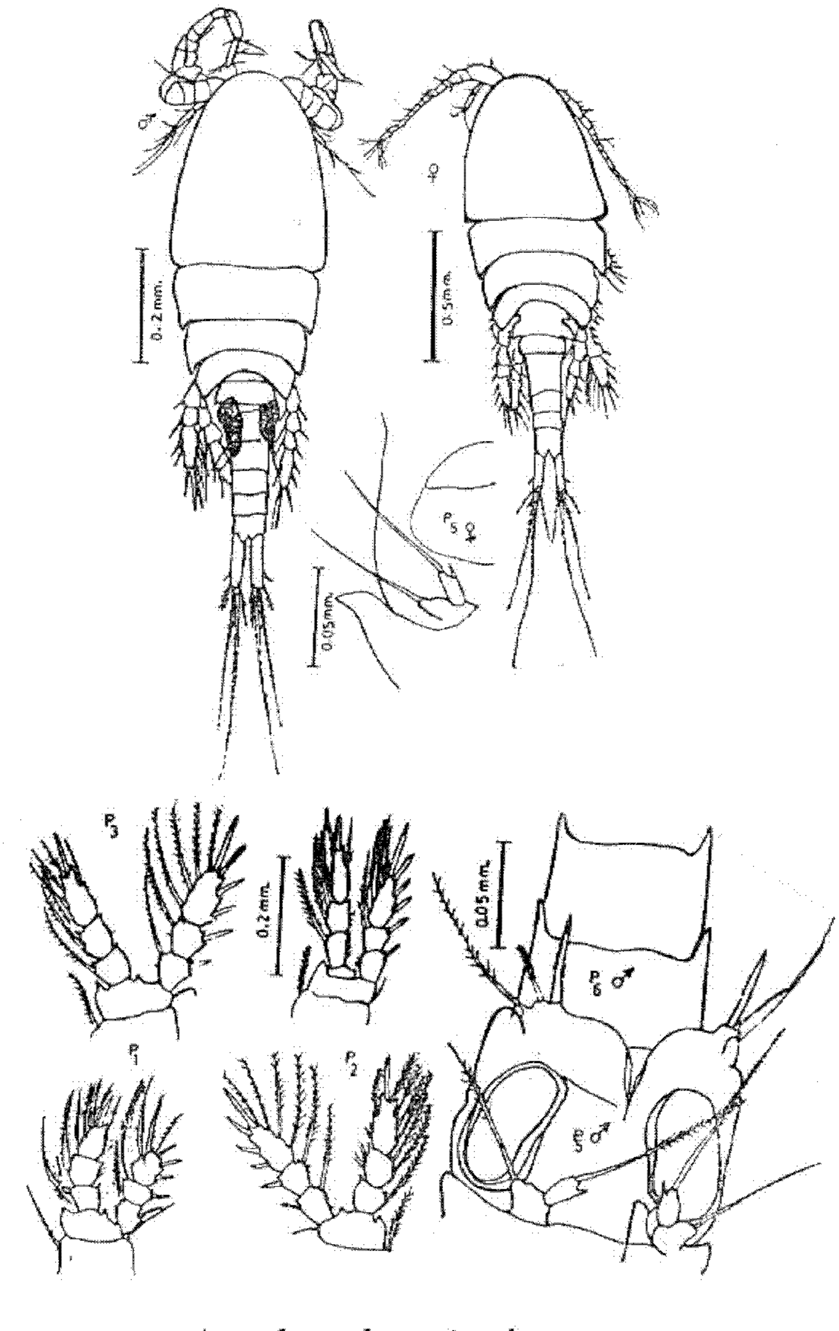


Mesocyclops leuckarti



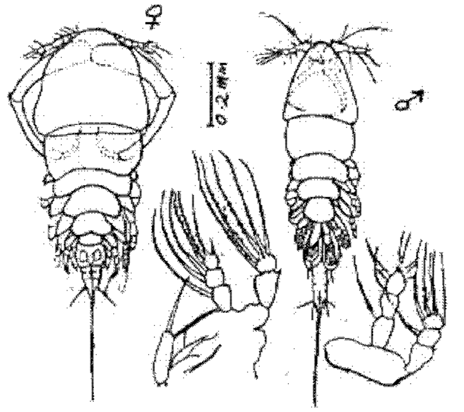
Diacyclops bicuspidatus

Plate 7.15

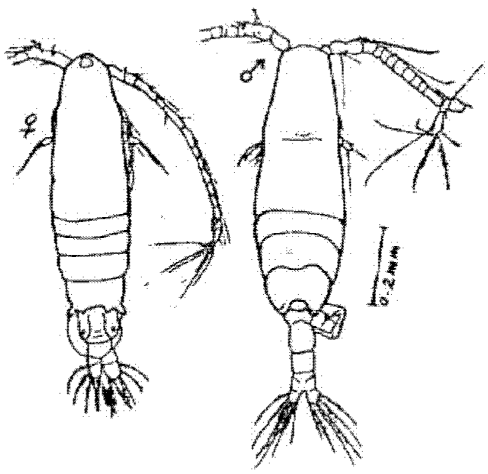


Acanthocyclops americanus

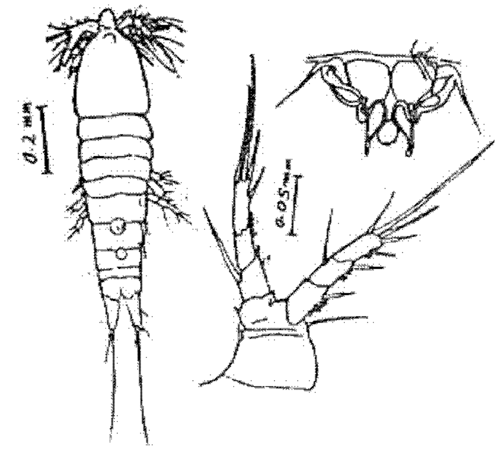
Plate 7.16



Ergasilus sieboldi



Acartia latisetosa



Canuella perplexa

Chapter 8
Macrobenthos

The benthic invertebrates in aquatic ecosystems play an important role in the transformation of the organic matter sediment on the bottom to its base elements and subsequently contribute to the basic nutrition of fish. The composition of the benthic fauna has largely been considered as a good indicator of water quality because, unlike planktonic species, they form relatively stable communities in the sediments which do not change over long time intervals and reflect characteristics of both sediments and upper water layer.

The few studies, which specially deal with benthic fauna in Lake Burullus include Aboul-Ezz (1984), who stated that the most important bottom dwellers inhabiting the Lake were *Gammarus, Corophium* (Amphipoda), *Mesenthura* (Isopoda), *Cheatogaster* (Oligochaeta) and *Corbicula* (Bivalvia). Samaan *et al.* (1989a) mentioned that the highest biomass of benthos appeared in the western region of the lake and decreased gradually eastwards. Samaan *et al.* (1989b) studied the general ecology and periodicity of the different changes in community structure, abundance and biomass of macrobenthos in relation to changes of lake hydrographic regime. Khalil and El-Shabrawy (2002) studied the biodiversity, density and population dynamics of macrobenthic invertebrates in Lake Burullus in relation to salinity and eutrophication changes of the lake. Bedir (2004) studied the ecological aspects of zooplankton and macrobenthos communities in relation to physical and chemical properties of Lake water.

8.1. BIODIVERSITY OF MACROBENTHOS

Throughout 2002 survey (Fig. 8.1), 33 benthic species belonging to three main groups (Arthropoda, Annelida and Mollusca) were recorded (Khalil and El-Shabrawy 2002). The benthic community consisted of 3 common species, 13 moderately common species, 11 rare species, and 6 very rare species (Table 8.1). There was no sign of the occurrence of 8 marine species which have been previously recorded in Lake Burullus by Aboul-Ezz (1984) and Anonymous (1984). These are: 3 of Arthropoda (*Mesanthura* sp., *Sphaeroma*

sp. and *Balanus improvisus*), 2 of Annelida (*Chaetogaster limnaei* and *Ficopomatus enigaticus*), and 3 of Mollusca (*Cerastoderma edula, Cerastoderma glaucum* and *Abra ovata*).

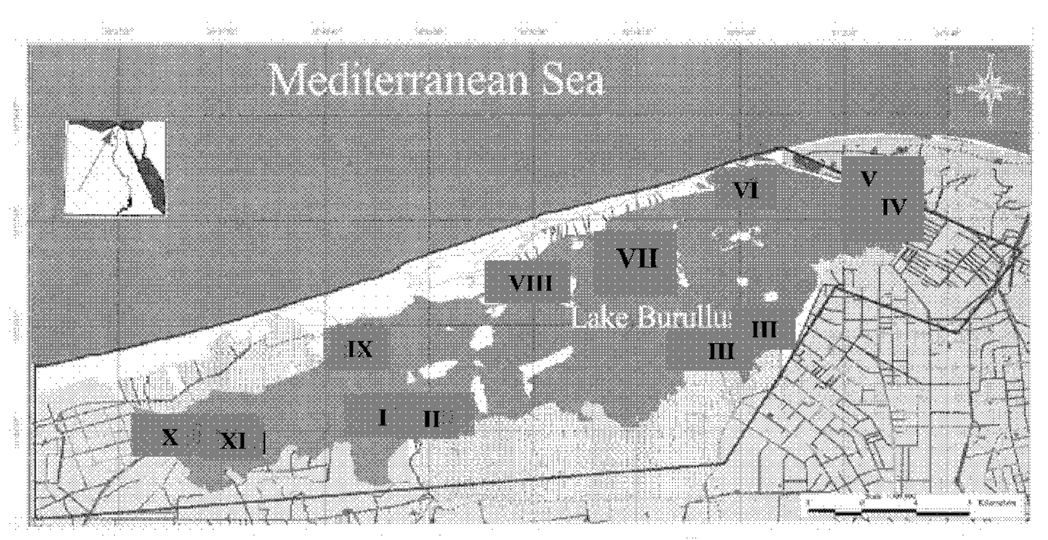


Fig. 8.1. **Map of Lake Burullus showing the location of sampling sites (after Khalil & El-Shabrawy 2002).**

Seventeen benthic species (fresh water in origin) were recorded for the first time in the Lake during 2002. The majority of these species were highly associated with the lake macrophytes these were: 7 of Arthropoda (Nymph of *Neurocordula* sp., Nymph of *Ischneura* sp., Nymph of *Enallaga vansomerni, Micronecta plicata, Lethocerus niloticus, Sternolophus solieri* and aquatic spiders), 7 of Annelida (*Branchiura sowerbyi, Limnodrilus hoffmeisteri, Limnodrilus udekemianus, Limnodrilus claparedeianus, Potamothrix hammoniensis, Helobdella conifera* and *Salifa perspicax*) and 3 of Mollusca (*Bellamya unicolor, Hydrobia ventrosa* and *Succinea cleopatra*).

8.2. SEASONAL VARIATION OF COMMON SPECIES

8.2. 1. Arthropoda

8.2.1.1. *Corophium orientale*

Corophium orientale was the most common and dominant benthic species in Lake Burullus, forming 87.4% and 72.1% of the total arthropod number and biomass, respectively (Khalil and El-Shabrawy 2002). Two density peaks with summer (Tables 8.2 and 8.3 and Figs. 8.2 and 8.3). In reference to species

Table 8.1**: Checklist of benthos species recorded in Lake Burullus during different time periods (1978-2002). C: Common, MC: Moderately Common, R: Rare, VR: Very Rare, F.W. Fresh water, M.W. Marine water. (1978 & 1979: after Aboul-Ezz 1984; 1982: after Anon. 1984; 2001 - 2002: after Khalil & El-Shabrawy 2002).**

Species	1978 1979	1982	2001 2002	Present status	Habitat	Location
Arthropoda						
Corophium volutator (Pallas)	+				M.W.	Lake Sediment
Corophium orientale (Schellenberg)		+	+	C	F.&M.W.	Lake Sediment
Gammarus lacustris (Fabricius)	+				F.&M.W.	Macrophytes associated
Gammarus aequicauda		+	+	MC	F.&M.W.	Macrophytes associated
Gammarus orinicornis		+			F.&M.W.	Macrophytes associated
Mesanthura sp.	+				F.&M.W.	Under Rocks
Sphaeroma sp.		+			M.W.	Macrophytes associated
Balanus improvisus		+			M.W.	Macrophytes associated
Palaemon elegans		+	+	MC	F.&M.W.	Macrophytes associated
Pasiphaeidae sp.		+			M.W.	Lake Sediment
Mysis relicta (Loven)	+		+	R	M.W.	Macrophytes associated
Tandipos tentans (Meigen)	+	+	+	R	F.&M.W.	Macrophytes associated
Nymph of *Neurocordula* sp.			+	VR	F.W.	Macrophytes associated
Nymph of *Ischneura* sp. (Pinhey)			+	VR	F.W.	Macrophytes associated
Nymph of *Enallaga vansomerni*			+	R	F.W.	Macrophytes associated
Micronecta plicata (Costa)			+	MC	F.W.	Macrophytes associated
Lethocerus niloticus (Stal)			+	R	F.W.	Macrophytes associated
Sternolophus solieri (Lapouge)			+	R	F.W.	Macrophytes associated
Decapod zoeae		+	+	MC	F.&M.W.	Macrophytes associated
Aquatic spiders			+	VR	F.W.	Macrophytes associated
Annelida						
Branchiura sowerbyi (Beddard)			+	MC	F.W.	Lake Sediment
Limnodrilus hoffmeisteri (Claparede)			+	C	F.W.	Lake Sediment
Limnodrilus udekemianus (Claparede)			+	MC	F.W.	Lake Sediment
Limnodrilus claparedeianus (Ratzel)			+	MC	F.W.	Lake Sediment
Potamothrix hammoniensis (Mich)			+	C	F.W.	Lake Sediment
Chaetogaster limnaei (K. Von Beak)	+				F.W.	Lake Sediment
Nereis limnoicola (Johnson)	+				F.W.	Lake Sediment
Nereis diversicolor		+	+	R	M.W.	Rocks and Shells
Ficopomatus enigaticus		+			M.W.	Rocks and Shells
Helobdella conifera (Moore)		+	+	VR	F.W.	Rocks and Shells
Salifa perspicax (Blanchard)			+	VR	F.W.	Rocks and Shells
Glossiphonia sp.		+			F.W.	Rocks and Shells
Mollusca						
Melanoides tuberculata (Müller)	+	+	+	MC	F.W.	Macrophytes and sed.
Theodoxus niloticus (Reeve)	+	+	+	MC	F.W.	Macrophytes and sed.
Buliuns truncatus (Audouin)		+	+	R	F.W.	Macrophytes
Gyraulus ehrenbergi (Beck)		+	+	R	F.W.	Macrophytes
Physa acuta (Draparanud)		+	+	VR	F.W.	Macrophytes
Cleopatra bulimoides (Olivier)		+	+	MC	F.W.	Macrophytes
Bellamya unicolor (Olivier)			+	MC	F.W.	Macrophytes
Lanistes carinatus (Olivier)		+	+	R	F.W.	Macrophytes
Biomphalaria alexandrina (Ehr.)		+	+	R	F.W.	Macrophytes
Hydrobia ventrosa (Montagu)			+	MC	F.W.	Lake Sediment
Succinea cleopatra (Pallary)			+	MC	F.W.	Lake Sediment
Corbicula consobrina (Cailliaud)	+				F.W.	Mcrophytes
Corbicula fluminalis (Müller)		+	+	R	F.W.	Lake Sediment
Abra ovata		+			M.W.	Lake Sediment
Cerastoderma glaucum		+			M.W.	Lake Sediment
Cerastoderma edula	+				M.W.	Lake Sediment

biomass, it was more or less following its standing crop, except during spring when heavy biomass individuals were present. The highest biomass value of *Corophium orientale* was 43.63 g wet wt. m^{-2}, recorded at station IV in spring, while it was infrequently recorded at the western sector of the lake. Moller and Rosenberg (1982) mentioned that *Corophium volutator* has two annual generations in the coast of Sweden. *C. orientale* seems to have two generations in Lake Burullus. Contrarily to this study, Hickin *et al.* (1980) showed that *C. volutator* was the most abundant both numerically and in biomass in summer. El-Shabrawy (1996) recorded 3 density peaks of *C. orientale* in Wadi El-Rayan lakes during April, August and November. Anderson (1972) mentioned that *Corophium* in general inhabits sediments predominantly of silt-size particles, while Stopfer (1951) and Gee (1961) advocated that this genus was found in mud or muddy sand, containing approximately 37% silt or clay. They also reported that it was not found in heavy polluted areas.

8.2.1.2. *Gammarus aequicauda*

Khalil and El-Shabrawy (2002) recorded a few individuals of this species at station IV in spring and at stations I, III, VII and XI during summer. *Gammarus aequicauda* was common in the macrophytes belt in Lake Burullus. This agrees with the findings of Ezzat (1959), Samaan and Aleem (1972), Samaan (1977), Anon. (1984), Ibrahim (1993) and El-Shabrawy (1996). They stated that *Gammarus* mainly lived among the leaves of macrophytes and fed on the epiphytes growing on them.

Table 8.2. **Standing crop of *Corophium orientale* (ind. m^{-2}) in Lake Burullus during 2001/02.**

Station	Autumn	Winter	Spring	Summer	Average
I	180	0	2700	0	**720**
II	270	90	90	45	**124**
III	1935	270	270	0	**619**
IV	225	360	6885	0	**1868**
V	5040	45	180	90	**1339**
VI	5400	2655	2520	0	**2644**
VII	855	360	270	0	**371**
VIII	90	45	1890	135	**540**
IX	270	0	585	45	**225**
X	0	0	45	0	**11**
XI	+	0	45	0	**15**
Average	**1427**	**348**	**1407**	**29**	**803**

Table 8.3. **Biomass of *Corophium orientale* (wet wt. m^{-2}) in Lake Burullus during 2001/02 (after Khalil & El-Shabrawy 2002).**

Station	Autumn	Winter	Spring	Summer	Average
I	0.66	0.00	8.78	0.00	**2.36**
II	1.36	0.39	0.48	0.19	**0.61**
III	10.88	1.33	1.11	0.00	**3.33**
IV	1.39	1.17	43.63	0.00	**11.55**
V	15.17	0.20	0.59	0.45	**4.10**
VI	14.89	6.94	16.38	0.00	**9.55**
VII	3.12	1.08	1.62	0.00	**1.46**
VIII	0.28	0.32	6.93	0.59	**2.03**
IX	1.09	0.00	3.15	0.28	**1.13**
X	0.00	0.00	0.21	0.00	**0.05**
XI	+	0.00	0.33	0.00	**0.11**
Average	**4.88**	**1.04**	**7.56**	**0.14**	**3.41**

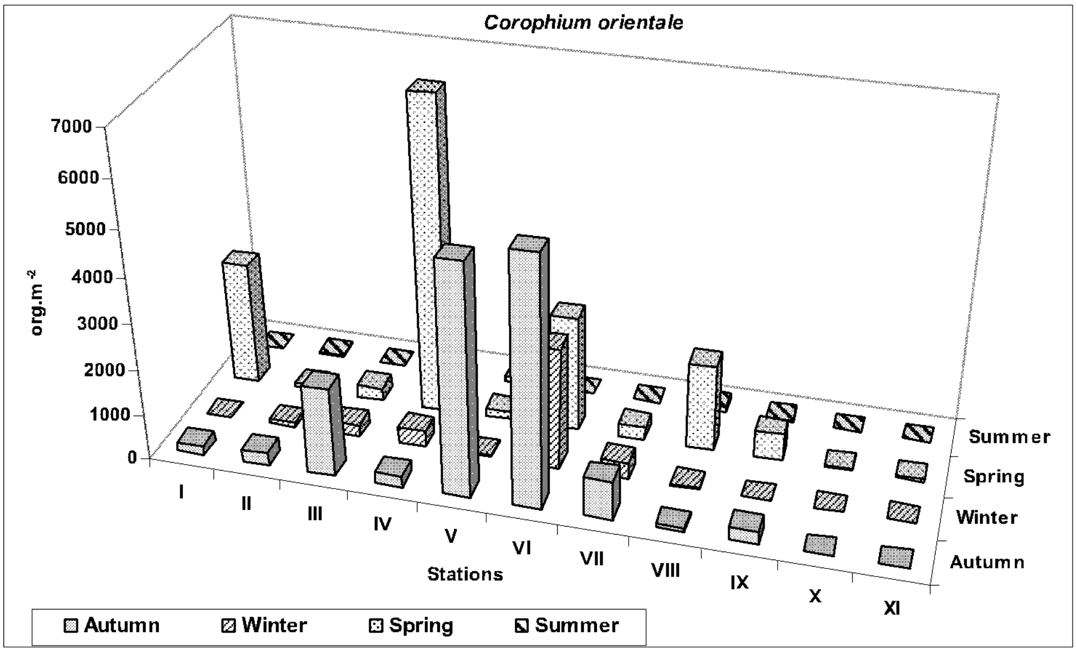


Fig. 8.2. **Standing crop of *Corophium orientale* in Lake Burullus during 2001/02.**

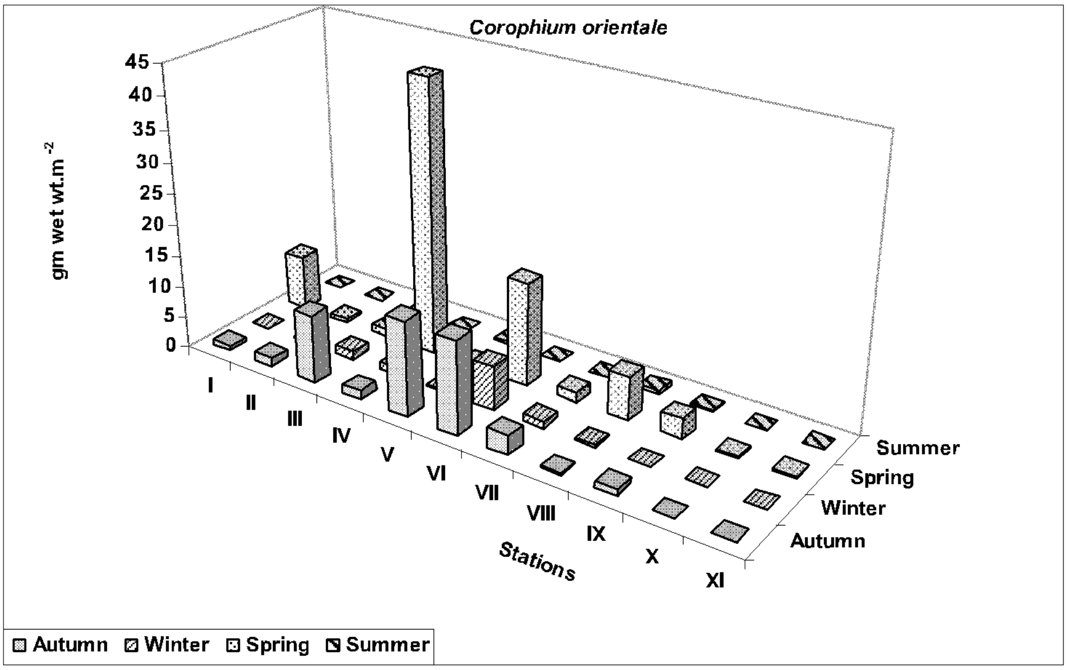


Fig. 8.3. **Biomass of *Corophium orientale* in Lake Burullus during 2001/02. (Khalil & El-Shabrawy 2002).**

8.2.2. Annelida

8.2.2.1. *Limnodrilus hoffmeisteri*

Limmodrilus hoffmeisteri, numerically, is the most predominant bottom animal inhabiting Lake Burullus. Khalil and El-Shabrawy (2002) recorded it at all sampling stations during the entire period of their study. *L. hoffmeisteri* contributed 72.7 and 45.8 % of total annelids count and biomass, respectively, with annual average of 1173 ind. m^{-2}, weighing 1.51 g fresh wt. m^{-2}. The flourishing of this species has been recorded in spring with a major peak of 9450 ind. m^{-2} at station VIII. The lowest abundance of this species was during autumn (Tables 8.4 and 8.5 and Figs. 8.4 and 8.5). Its biomass was generally proportional to its numbers. Qi Sang (1987) mentioned that *L. hoffmeisteri* is dominant and favored in organic polluted water, and it is known by its ability to tolerate low oxygen levels. Milbrink (1973) stated that *L. hoffmeisteri* inhabits polluted lakes together with *L. edukemianus* and *L. claparedeianus.* The same association of species was generally found to occur at grossly polluted sites of the Guangzhou Reach, which is located in the Subtropics (Qi Sang 1987) and Lake Burullus. Verdonschot (1987) stated that this species has a positive relation with pH, nitrate and bicarbonate. *L. hoffmeisteri* showed a positive relation with EC and organic matter in Lake Nasser (El-Shabrawy and Abdel-Regal 1999). It has been defined in the literature as an eutrophic species (Milbrink 1979, 1980; Lang & Lang Dobler 1980).

Table 8.4. **Standing crop of *Limnodrilus hoffmeisteri* (ind. m^{-2}) in Lake Burullus during 2001/02.**

Station	Autumn	Winter	Spring	Summer	Average
I	90	180	5766	2900	**2234**
II	0	1980	4635	2250	**2216**
III	45	90	270	90	**124**
IV	0	90	2115	135	**585**
V	90	270	1350	360	**518**
VI	45	90	5940	90	**1541**
VII	90	90	4500	2610	**1823**
VIII	45	45	9450	720	**2565**
IX	45	90	900	1665	**675**
X	45	270	270	675	**315**
XI	+	0	360	810	**390**
Average	**50**	**290**	**3232**	**1119**	**1173**

Table 8.5. **Biomass of *Limnodrilus hoffmeisteri* (g wet wt. m^{-2}) in Lake Burullus during 2001/ 02 (after Khalil & El-Shabrawy 2002).**

Station	Autumn	Winter	Spring	Summer	Average
II	0.00	1.72	5.78	2.78	**2.57**
III	0.09	0.20	0.42	0.10	**0.20**
IV	0.00	0.14	2.84	0.18	**0.79**
V	0.13	0.65	1.54	0.28	**0.65**
VI	0.02	0.24	8.02	0.16	**2.11**
VII	0.28	0.15	5.26	3.48	**2.29**
VIII	0.08	0.08	13.89	0.88	**3.73**
IX	0.10	0.18	1.14	2.22	**0.91**
X	0.07	0.55	0.42	0.58	**0.41**
XI	+	0.00	0.50	0.86	**0.45**
Average	**0.09**	**0.39**	**4.26**	**1.31**	**1.51**

8.2.2.2. *Potamothrix hammoniensis*

Potamothrix hammoniensis ocuupied the second predominant position among annelids, contributing 13.7% of the total number of annelids and 7.9% of its biomass (Khalil and El-Shabrawy 2002). This species is wide spread in the Lake, but not abundant anywhere. The highest standing crop of 401 ind. m^{-2} weighing 0.47 g wet. wt. m^{-2} occurred in winter, while the least yield of 78 ind. m^{-2} weighing 0.04 g was recorded in summer (Tables 8.6 and 8.7 and Figs. 8.6 and 8.7). Verdonschot (1987) mentioned that this species has a positive linear correlation with pH and water depth. Milbrink (1980) stated that *P. hammoniensis* is one of the commonest species in shallow eutrophic lakes allover Europe. Timm *et al.* (2001) considered *P. hammoniensis* as a moderate pollution indicator.

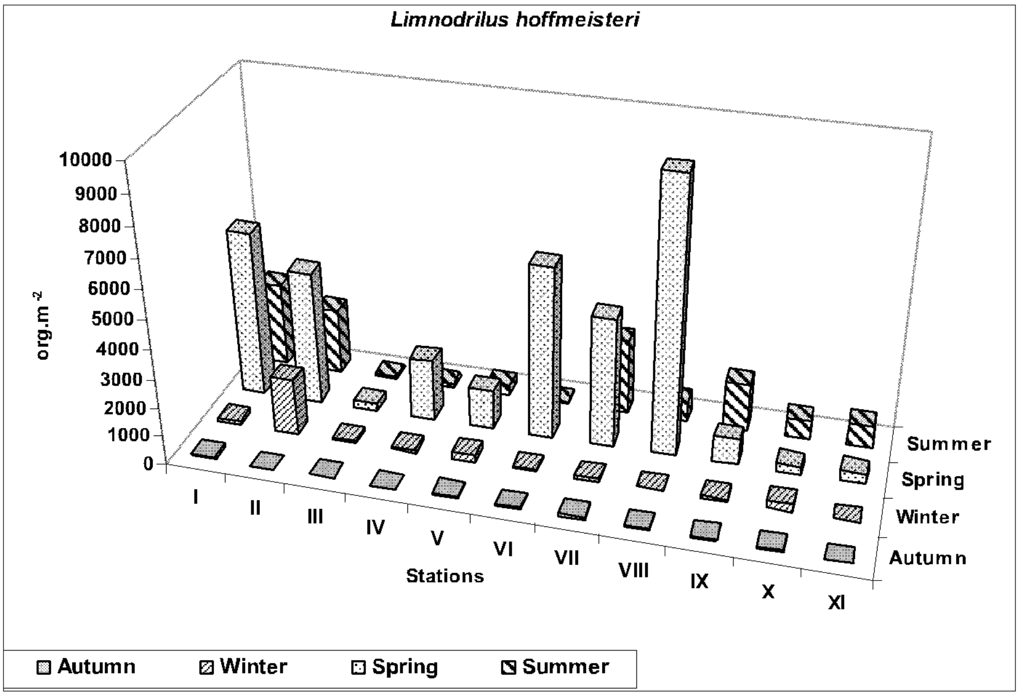


Fig.8.4. **Standing crop of *Limnodrilus hoffmeisteri* in Lake Burullus during 2001/02.**

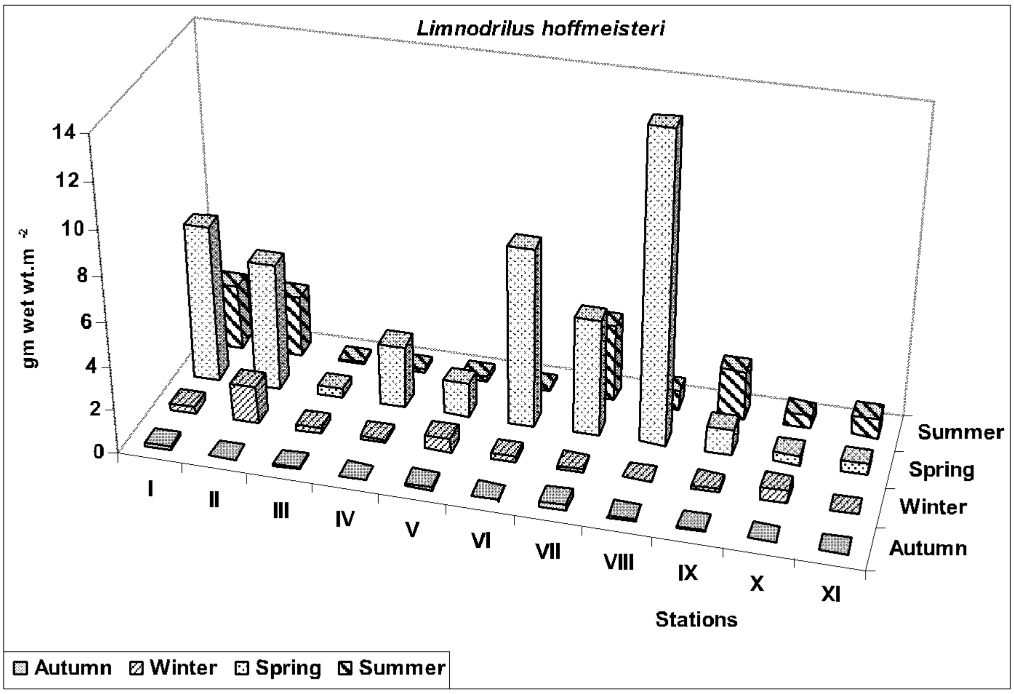


Fig. 8.5. **Biomass of *Limnodrilus hoffmeisteri* in Lake Burullus during 2001/02 (after Khalil & El-Shabrawy 2002).**

Table 8.6. **Standing crop of *Potamothrix hammoniensis* (ind. m^{-2}) in Lake Burullus during 2001/02.**

Station	Autumn	Winter	Spring	Summer	Average
I	0	45	225	90	**90**
II	450	1125	0	0	**394**
III	180	360	45	0	**146**
IV	45	450	900	0	**349**
V	45	495	270	45	**214**
VI	135	180	180	0	**124**
VII	180	315	90	90	**169**
VIII	90	360	675	90	**304**
IX	0	270	315	180	**191**
X	450	450	0	0	**225**
XI	+	360	0	360	**240**
Average	**158**	**401**	**245**	**78**	**220**

Table 8.7. **Biomass of *Potamothrix hammoniensis* (g wet wt. m^{-2}) in Lake Burullus during 2001 / 02 (after Khalil & El-Shabrawy 2002).**

Station	Autumn	Winter	Spring	Summer	Average
I	0.00	0.02	0.16	0.04	**0.06**
II	0.65	1.65	0.00	0.00	**0.58**
III	0.18	0.44	0.01	0.00	**0.16**
IV	0.16	0.61	1.08	0.00	**0.46**
V	0.20	0.59	0.13	0.01	**0.23**
VI	0.19	0.15	0.06	0.03	**0.11**
VII	0.24	0.46	0.02	0.01	**0.18**
VIII	0.38	0.28	0.78	0.07	**0.38**
IX	0.00	0.31	0.42	0.00	**0.18**
X	0.99	0.32	0.00	0.00	**0.33**
XI	+	0.33	0.00	0.24	**0.19**
Average	**0.30**	**0.47**	**0.24**	**0.04**	**0.26**

8.2.2.3. *Branchiura sowerbyi*

Branchiura sowerbyi was infrequently recorded in Lake Burullus during 2002 (Khalil and El-Shabrawy 2002). Contrarily to its low numbers (avr. 35 ind. m^{-2}, forming 2.2 % of total annelids account) the contribution of this species to annelids biomass is high (29.1 %). *B. sowerbyi* had long duration in the lake during spring, while it was restricted only to stations I and III during the rest of year. The biomass of this species exhibits a positive correlation to its count. Milbrink (1973) mentioned that *B. sowerbyi* is an indicator of warm water and is known to tolerate high degree of organic pollution. El-Shabrawy and Abdel-Regal (1999) infrequently recorded this species in Lake Nasser.

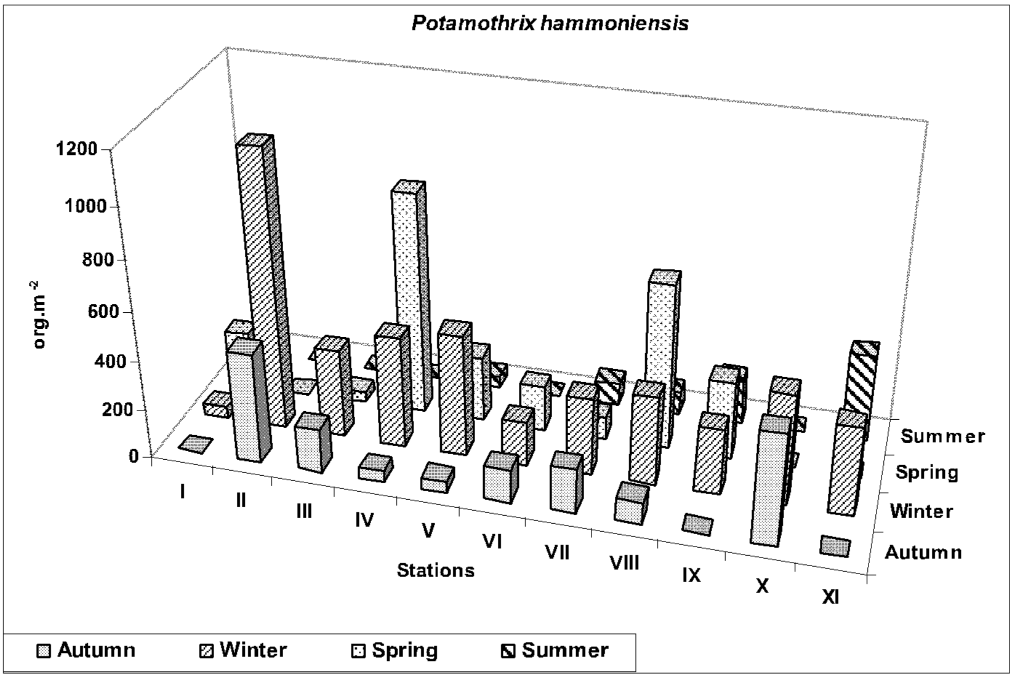


Fig. 8.6. **Standing crop of *Potamothrix hammoniensis* in Lake Burullus during 2001/02.**

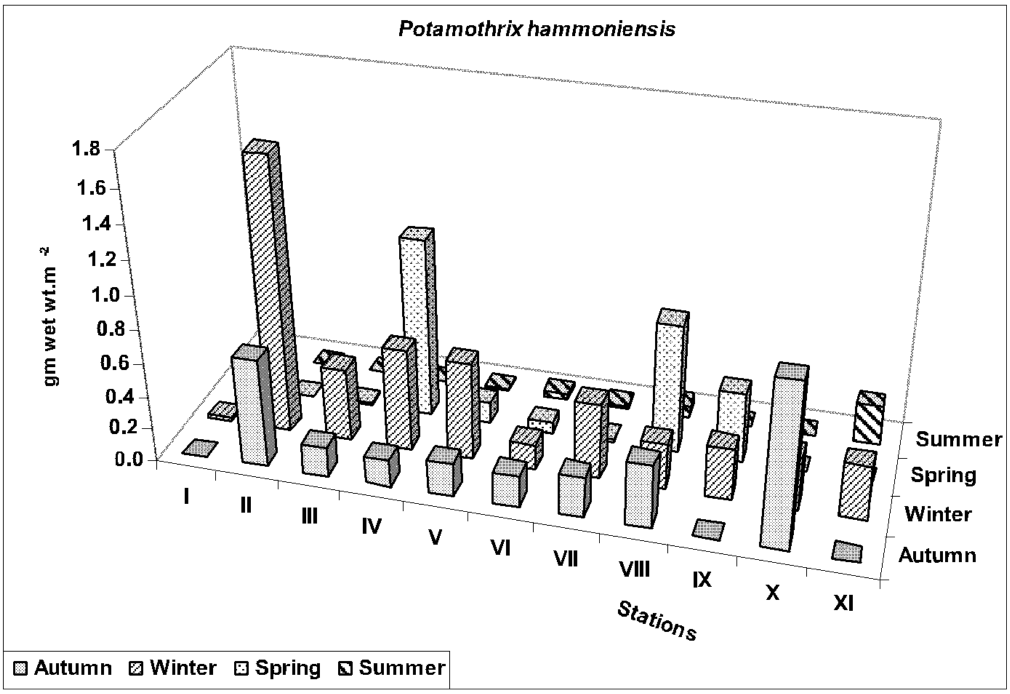


Fig. 8.7. **Biomass of *Potamothrix hammoniensis* in Lake Burullus during 2001/02 (after Khalil & El-Shabrawy 2002).**

8.2.3. Mollusca

8.2.3.1. *Melanoides tuberculata*

Melanoides tuberculata is the most common gastropod in Lake Burullus and occupied the first position, regarding standing crop of total molluscs, forming 42.2 % of its total numbers (Khalil and El-Shabrawy 2002). The share of this species in molluscan biomass was relatively low (23.4%). Summer showed highest abundance of this species (avr. 180 ind. m^{-2} weighing 8.68 g wet wt. m^{-2}), while it was poorly represented during the rest of year (Tables 8.8 and 8.9 and Figs. 8.8 and 8.9). The biomass of this species followed the same general trend as its count. *M. tuberculata* is widely distributed, not only in Africa (Brown 1980) but also in Asia (Fernando 1969). It lives in stagnant and slowly running waters, can tolerate a moderate salinity and is highly associated with aquatic macrophytes (Brown 1980 ; Ibrahim *et al.* 1999). In Lake Burullus, *M. tuberculata* was recorded in sediments as well as associated with macrophytes (Khalil and El-Shabrawy 2002).

8.2.3.2. *Theodoxus niloticus*

The perennial occurrence of this species is restricted to the western sectors of the lake (Khalil and El-Shabrawy 2002). It collectively contributed 17.1 and 6.5 % of the total molluscan standing crop and biomass, respectively. Autumn was relatively rich with this species with an average standing crop of 59 ind. m^{-2}. *T. niloticus* lives in all types of freshwater bodies. It usually occurs in colonies over and under rocky limestone and associated with many macrophytes (Ibrahim *et al.* 1999).

Table 8.8. **Standing crop of *Melanoides tuberculata* (ind. m^{-2}) in Lake Burullus during 2001/02.**

Station	Autumn	Winter	Spring	Summer	Average
II	45	0	0	0	**11**
III	0	0	0	450	**113**
IV	90	0	0	90	**45**
V	0	45	0	45	**23**
VI	0	0	0	45	**11**
VII	0	0	0	315	**79**
VIII	0	0	0	225	**56**
IX	45	0	0	180	**56**
X	135	90	90	270	**55**
XI	+	360	45	315	**240**
Average	**54**	**49**	**20**	**180**	**76**

Table 8.9. Biomass of _Melanoides tuberculata_ (g wet wt.m^{-2}) in Lake Burullus during 2001/02 (after Khalil & El-Shabrawy 2002).

Station	Autumn	Winter	Spring	Summer	Average
I	33.42	9.45	12.15	6.30	15.33
II	7.21	0.00	0.00	0.00	1.80
III	0.00	0.00	0.00	16.20	4.05
IV	3.47	0.00	0.00	3.46	1.73
V	0.00	0.72	0.00	1.80	0.63
VI	0.00	0.00	0.00	2.94	0.74
VII	0.00	0.00	0.00	28.35	7.09
VIII	0.00	0.00	0.00	0.45	0.11
IX	0.93	0.00	0.00	10.35	2.82
X	18.02	3.45	6.08	9.90	3.81
XI	+	12.94	0.93	15.75	7.41
Average	6.31	2.41	1.74	8.68	4.79

8.2.3.3. Bellamya unicolor

Khalil and El-Shabrawy (2002) recorded few individuals of this species (avr. 10 ind. m^{-2}), forming 5.7% of the total molluscans standing crop. In contrast to its count, *B. unicolor* plays a major role in formation of molluscan biomass.

8.3. COMMUNITY COMPOSITION AND LONG-TERM CHANGES

n Lake Burullus, a total of 33 benthic species were recorded. They belong to 3 main groups (Arthropoda, Annelida and Mollusca). The total benthos shows a wide regional and seasonal variation (Tables 8.10 and 8.11, Figs. 8.10 and 8.11). Regarding seasonal variation, spring maintained the highest abundance of these organisms, with a major peak of 13365 ind. m^{-2}, weighing 64.31 g wet wt. m^{-2}. The lowest yield of these invertebrate organisms occurred in winter. Aboul-Ezz (1984) recorded only 11 species with standing crop of 440 ind. m^{-2}, weighing 13.7 g wet wt. m^{-2}. During 2002 study (Khalil and El-Shabrawy 2002) the standing crop of the benthos remarkably increased to 2707 ind. m^{-2} weighing 28.48 g wet wt. m^{-2}. Annelida and Mollusca were found to have the highest percentage frequency (%) of benthos standing crop and biomass, respectively (Fig. 8.12).

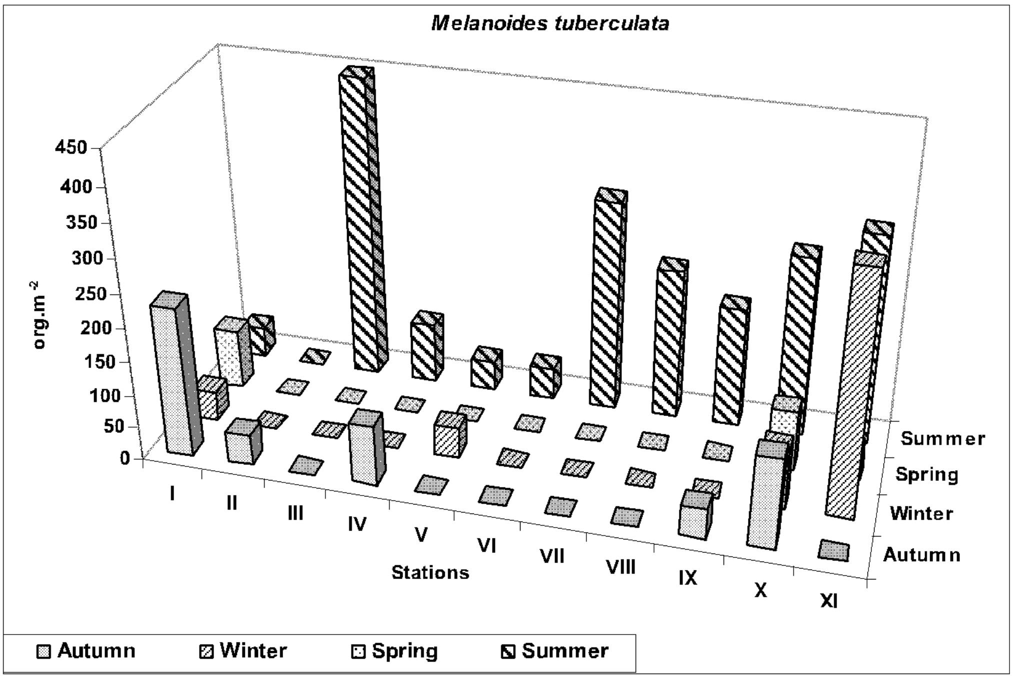


Fig. 8.8. **Standing crop of *Melanoides tuberculata* in Lake Burullus during 2001/02.**

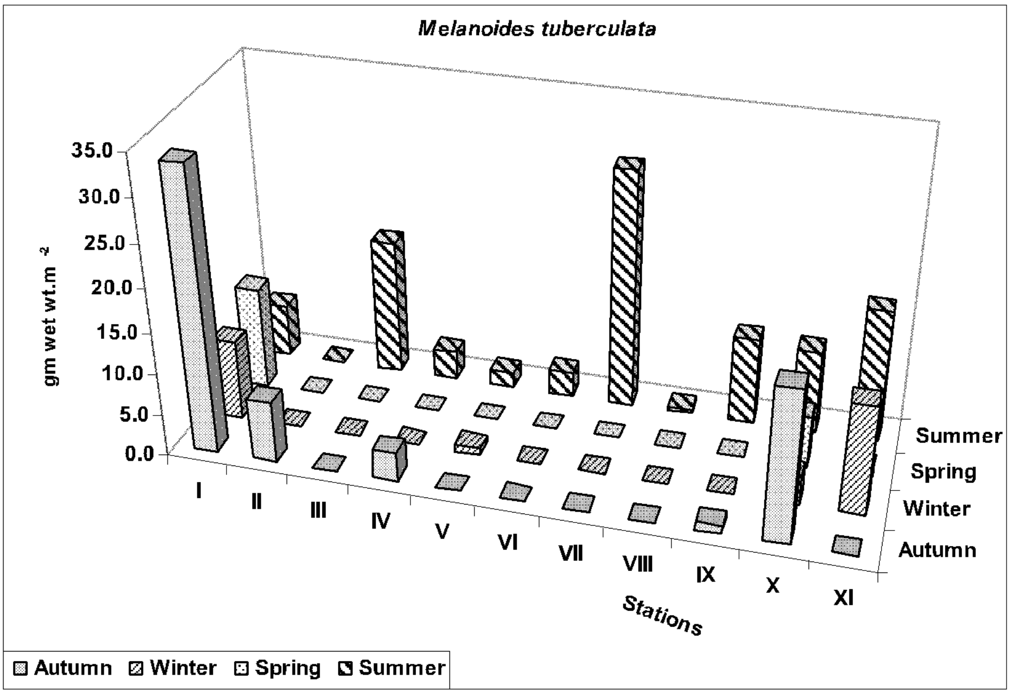


Fig. 8.9. **Biomass of *Melanoides tuberculata* in Lake Burullus during 2001/02 (after Khalil & El-Shabrawy 2002).**

Table 8.10. **Standing crop of total benthos (ind. m^{-2}) in Lake Burullus during 2001/02 (after Khalil & El-Shabrawy 2002).**

Station	Autumn	Winter	Spring	Summer	Average
II	1215	3780	5265	2565	**3206**
III	2385	1035	1170	945	**1384**
IV	450	1080	10125	315	**2993**
V	5175	855	2295	765	**2273**
VI	5580	2925	9945	765	**4804**
VII	1350	810	5445	4455	**3015**
VIII	360	540	13365	1350	**3904**
IX	585	720	1980	2430	**1429**
X	1125	1305	765	1170	**1091**
XI	+	1035	720	2385	**1380**
Average	**1908**	**1338**	**5645**	**1937**	**2707**

Table 8.11. **Biomass of total benthos (g wet wt. m^{-2}) in Lake Burullus during 2001/02 (after Khalil & El-Shabrawy 2002).**

Station	Autumn	Winter	Spring	Summer	Average
I	97.08	80.21	61.89	154.77	**98.49**
II	43.31	5.88	37.03	5.66	**22.97**
III	69.25	36.21	3.88	30.79	**35.03**
IV	7.05	4.63	69.30	4.70	**21.42**
V	15.50	2.16	3.00	103.43	**31.02**
VI	15.10	7.33	26.06	4.56	**13.26**
VII	4.20	1.70	7.44	63.07	**19.10**
VIII	5.27	0.86	64.31	11.16	**20.40**
IX	11.67	4.61	5.52	13.20	**8.75**
X	26.06	13.59	42.82	11.70	**30.05**
XI	+	19.98	6.50	21.22	**11.93**
Average	**29.45**	**16.11**	**29.80**	**38.57**	**28.48**

Annelida is considered the most common and abundant group among the bottom animals in Lake Burullus. It constituted about 59.6% of the total benthos numbers, with annual average of 1613 ind. m^{-2}. However, their participation in benthos biomass is small, forming only 11.6%. The population density of these organisms reached its maximum in spring (3837 ind. m^{-2}), weighing 6.89 g wet wt. m^{-2}; while autumn sustained the lowest yield of 243 ind. m^{-2}, weighing 1.21 g wet wt. m^{-2}. The Annelida biomass had a positive relation with its numbers, except in winter when relatively a small number with heavy biomass occurred (Tables 8.12 and 8.13, Figs. 8.13 and 8.14). Khalil and El-Shabrawy (2002)

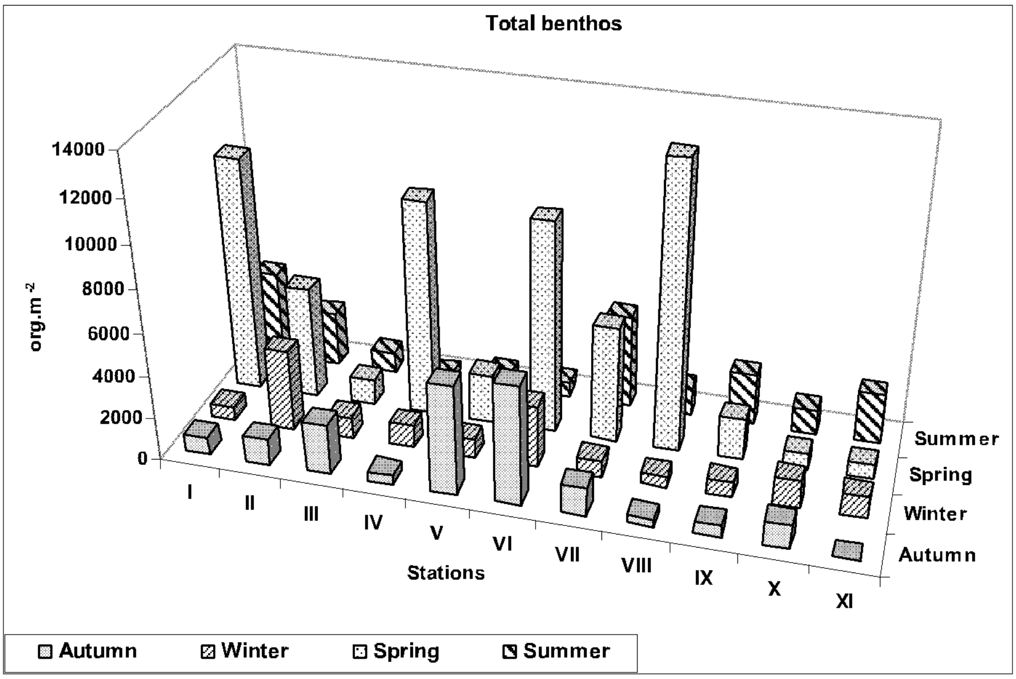


Fig. 8.10. **Standing crop of total benthos in Lake Burullus during 2001 / 02.**

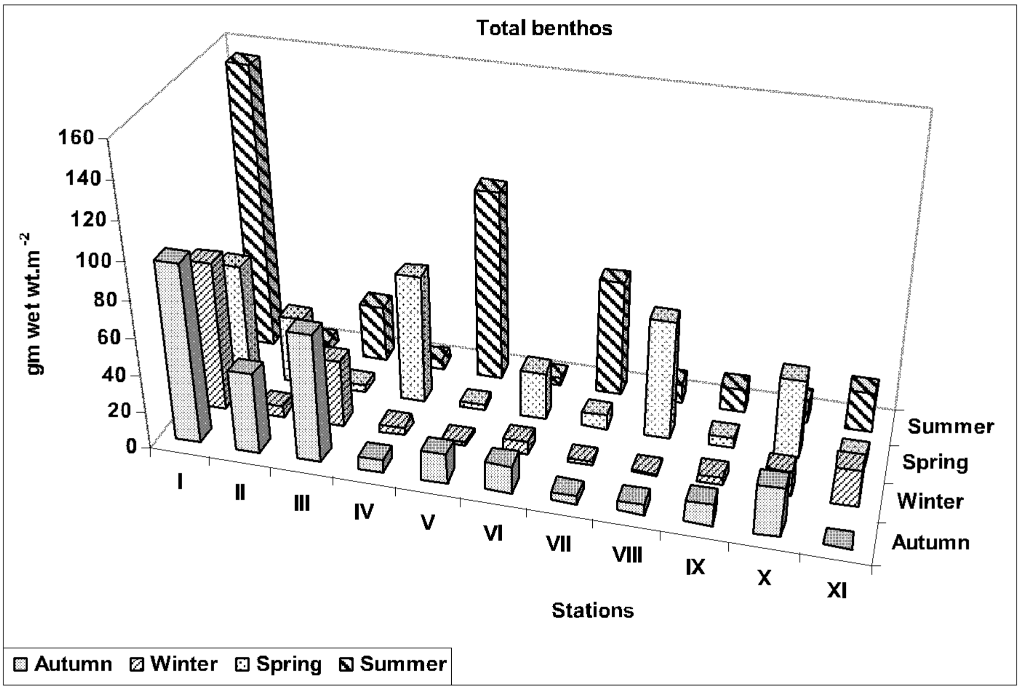
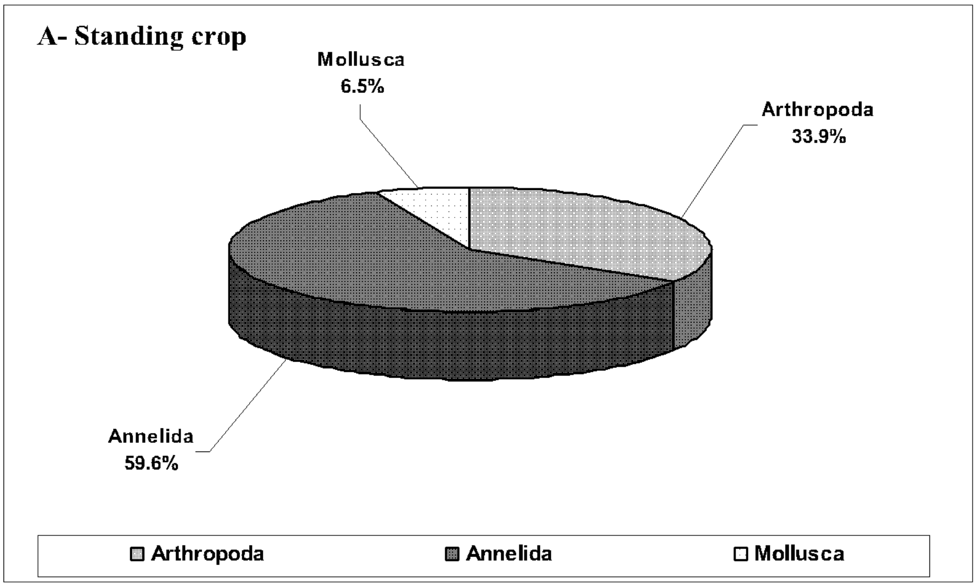


Fig. 8.11. **Biomass of total benthos in Lake Burullus during 2001/ 02**



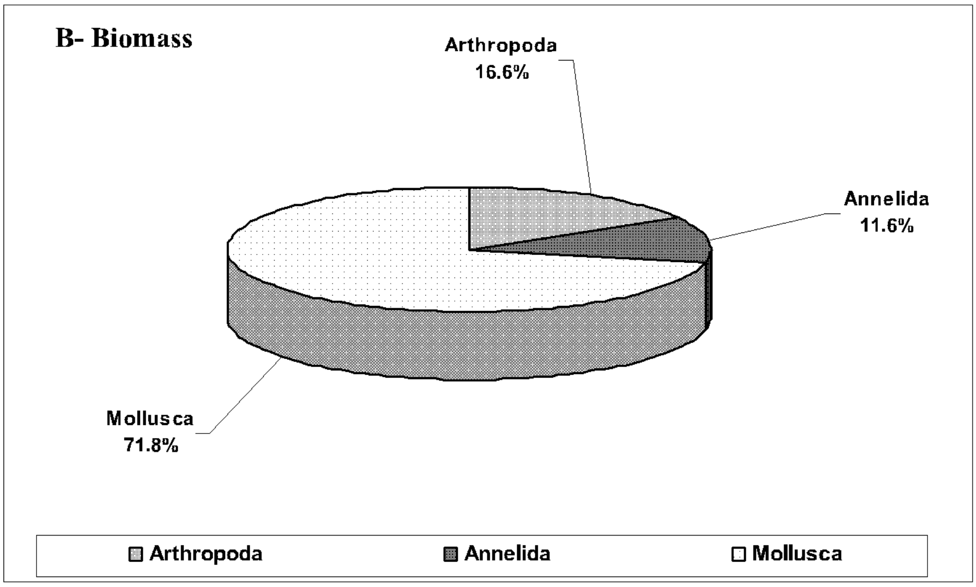


Fig. 8.12. **Community composition of total benthos during 2002**

Table 8.12. **Standing crop of total Annelida in Lake Burullus during 2001/02.**

Station	Autumn	Winter	Spring	Summer	Average
I	315	315	6615	3710	**2739**
II	495	3465	5040	2475	**2869**
III	270	675	450	180	**394**
IV	45	675	3060	180	**990**
V	135	765	1980	540	**855**
VI	180	270	7020	675	**2036**
VII	270	450	5175	3825	**2430**
VIII	135	400	10845	990	**3093**
IX	45	495	1260	2205	**1001**
X	540	900	360	810	**1823**
XI	+	450	405	1620	**825**
Average	**243**	**805**	3837	**1565**	**1613**

Table 8.13. **Biomass of total Annelida in Lake Burullus during 2001/ 02 (after Khalil & El-Shabrawy 2002).**

Station	Autumn	Winter	Spring	Summer	Average
I	6.75	2.29	9.41	10.94	**7.35**
II	1.60	3.71	27.49	3.60	**9.10**
III	0.90	6.66	0.47	0.96	**2.25**
IV	**0.16**	3.21	3.95	0.20	**1.88**
V	0.33	1.24	2.04	0.38	**1.00**
VI	0.21	0.39	8.85	0.69	**2.54**
VII	0.52	0.62	5.82	4.59	**2.89**
VIII	0.46	0.36	15.21	**1.12**	**4.29**
IX	0.10	3.37	1.59	2.57	**1.91**
X	1.07	6.00	0.47	0.62	**3.69**
XI	+	0.96	0.53	1.52	**0.75**
Average	**1.21**	**2.62**	**6.89**	**2.47**	**3.30**

recorded eight annelids species, while Aboul Ezz (1984) and Anonymous (1984) recorded only 2 and 4 species respectively. *Limnodrilus hoffmeisteri, Potamothrix hammoniensis* and *Branchiura sowerbi* are the most common annelids (Fig. 8.15).

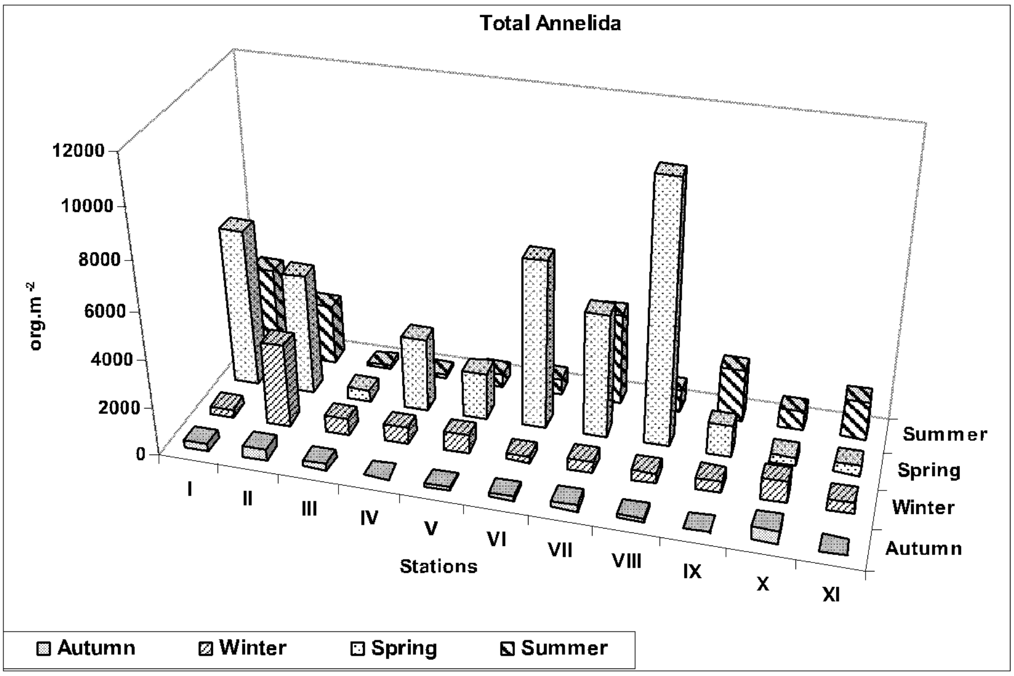


Fig. 8.13. **Standing crop of total Annelida in Lake Burullus during 2001/02.**

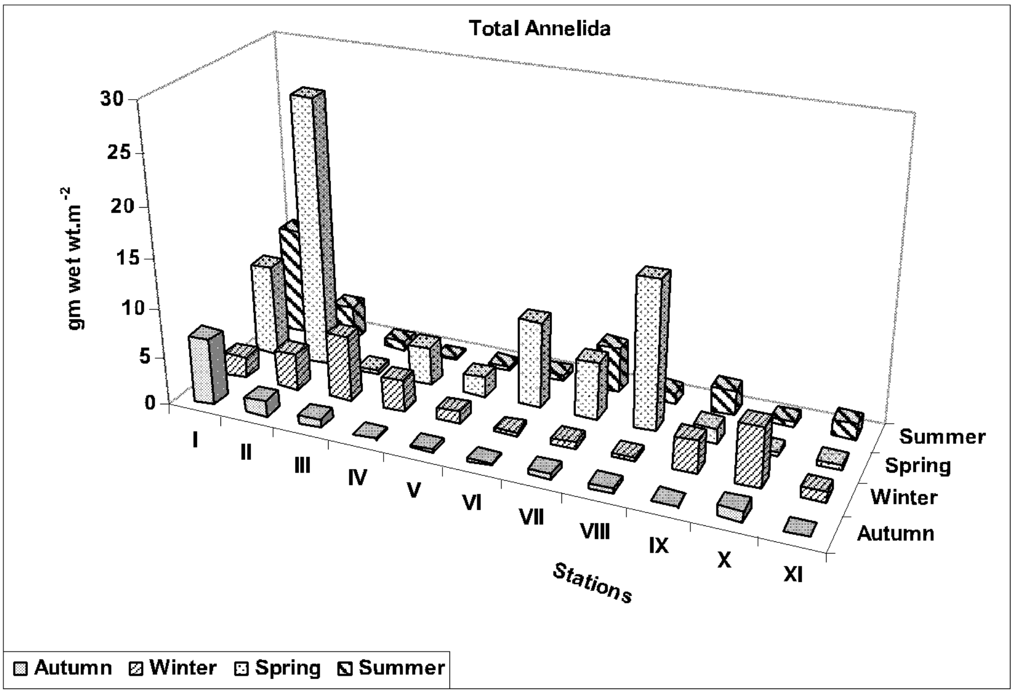


Fig. 8.14. **Biomass of total Annelida in Lake Burullus during 2001/02.**

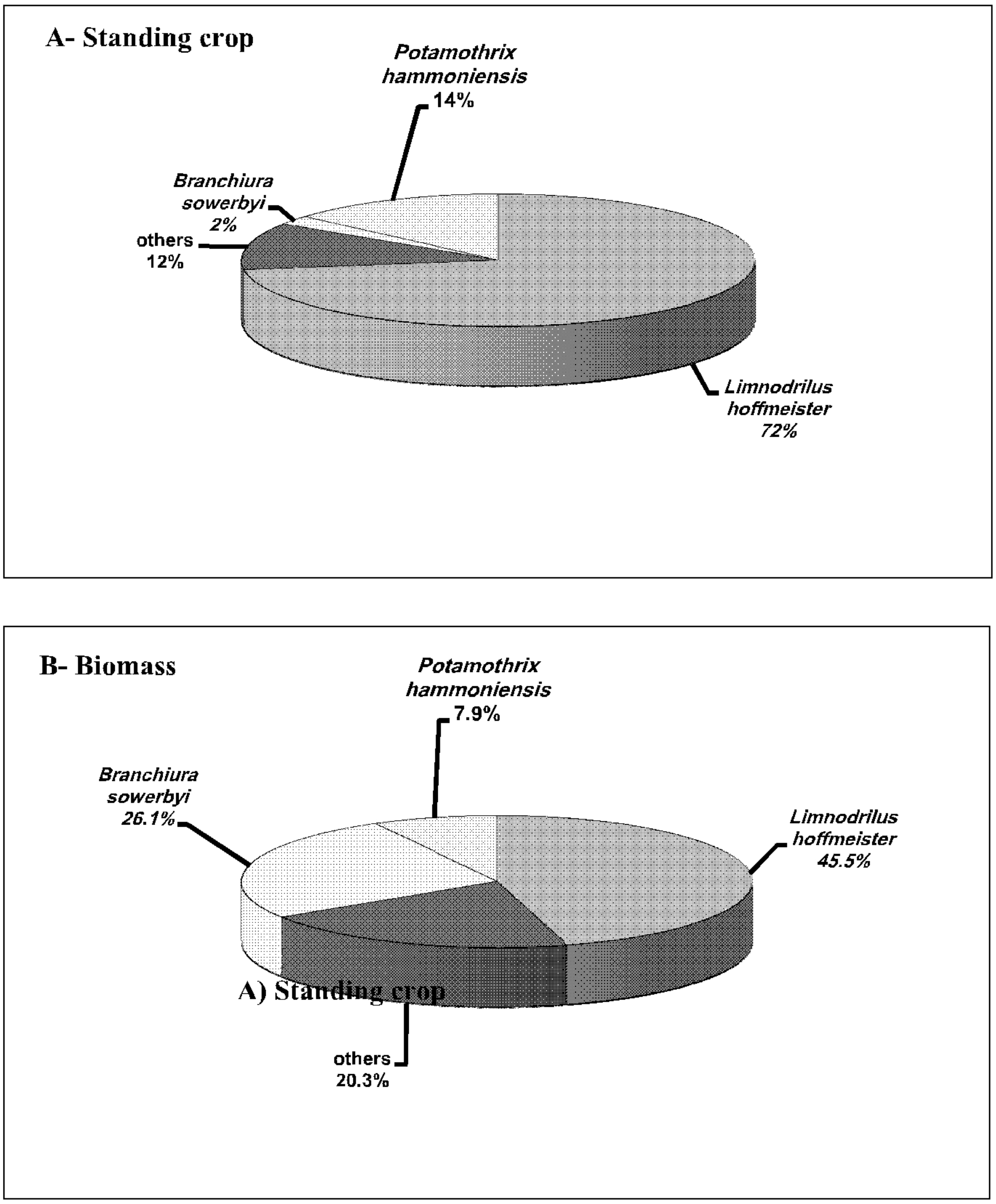


Figure 8.15. **Community composition of Total Annelida during 2002.**

Arthropoda occupies the second position among benthic groups, with an overall average of 919 ind. m^{-2}, contributing about 33.9% of the total benthos numbers. The highest population density of these animals occurred in spring (Avr. 1694 ind. m^{-2}), while summer was the poorest period sustaining these arthropods. Regarding biomass, spring maintained the highest value of 8.44 g wet wt. m^{-2}; while winter sustained the lowest (1.72 g wet wt. m^{-2}) (Tables 8.14 and 8.15, Figs. 8.16 and 8.17).

Table 8.14. **Standing crop of total Arthropoda (ind. m^{-2}) in Lake Burullus during 2001/02.**

Station	Autumn	Winter	Spring	Summer	Average
I	270	135	4275	90	**1193**
II	315	180	135	45	**169**
III	1935	270	360	225	**698**
IV	225	360	7020	45	**1913**
V	5040	45	270	90	**1361**
VI	5400	2655	2925	45	**2756**
VII	855	360	270	180	**416**
VIII	90	45	2475	135	**686**
IX	270	135	585	45	**259**
X	360	270	135	45	**1050**
XI	+	135	180	45	**120**
Average	**1476**	**417**	**1694**	**90**	**919**

Table 8.15. **Biomass of total Arthropoda (g wet wt. m^{-2}) in Lake Burullus during 2001 / 02 (after Khalil & El-Shabrawy 2002).**

Station	Autumn	Winter	Spring	Summer	Average
I	1.59	0.69	11.98	0.16	**3.61**
II	1.62	1.50	1.66	0.19	**1.24**
III	10.88	1.33	1.43	2.74	**4.10**
IV	1.39	1.17	44.47	1.04	**12.02**
V	15.17	0.20	0.75	0.45	**4.14**
VI	14.89	6.94	17.21	0.93	**9.99**
VII	3.12	1.08	1.62	29.67	**8.87**
VIII	0.28	0.32	8.30	0.59	**2.37**
IX	1.09	0.52	3.15	0.28	**1.26**
X	3.92	3.92	1.43	0.44	**5.29**
XI	+	1.22	0.81	0.21	**0.56**
Average	**5.40**	**1.72**	**8.44**	**3.34**	**4.72**

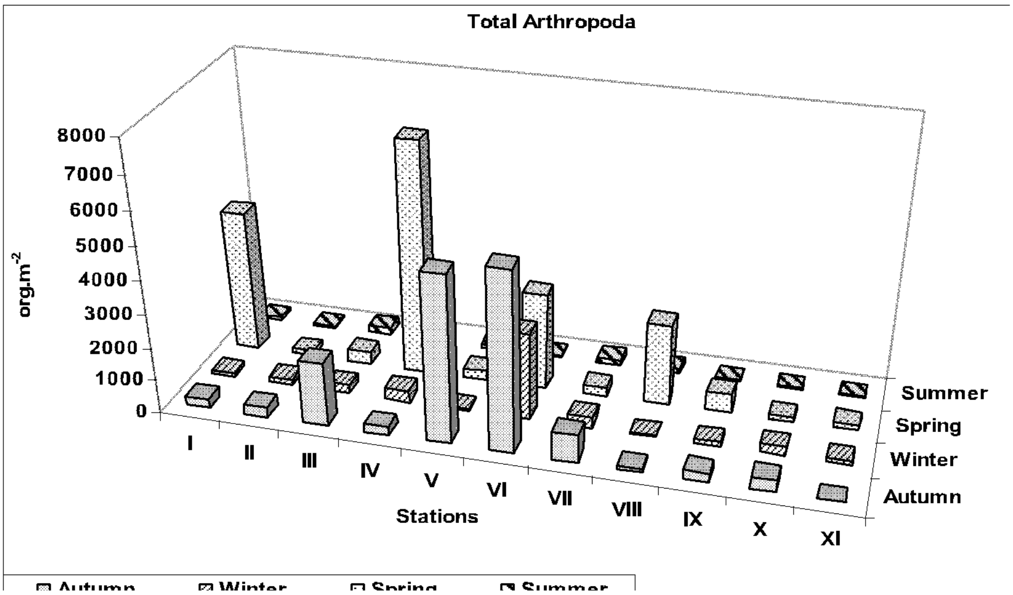


Fig. 8.16. **Standing crop of total Arthropoda in Lake Burullus during 2001/02.**

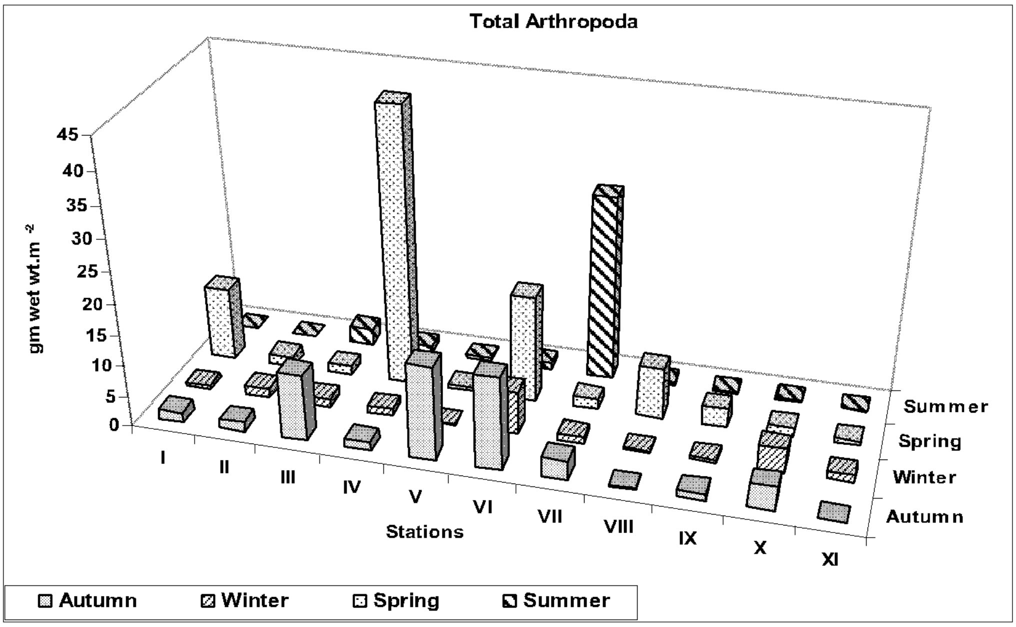


Fig. 8.17. **Biomass of total Arthropoda in Lake Burullus during 2001/02.**

Aboul-Ezz (1984) previously recorded 5 species of arthropods with standing crop of 208 ind. m^{-2}, weighing 0.39 g wet wt m^{-2} in 1978 - 1979, while Anonymous (1984) recorded 9 arthropods in 1982. Khalil and El-Shabrawy (2002) recorded 13 species of which *Corophium orientale* monopolized the other arthropods (Fig. 8.18).

Depending on the standing crop values, Mollusca occupied the 3rd position among the total benthos groups, with overall average of 175 ind. m^{-2}, forming 6.5 % of the total benthos number (Bedir 2004). In contrast with standing crop, mollusca plays a major role in formation of the total benthos biomass, contributing about 71.8%, with an average of 20.46 g wet wt. m^{-2}. On seasonal basis, summer was the richest with these organisms (282 ind. m^{-2}), weighing 32.79 g wet wt m^{-2}, while the least crop occurred in winter and spring (Tables 8.16 and 8.17 and Figs. 8.19 and 8.20). Aboul Ezz (1984) recorded 4 molluscan species during 1978 – 1979 in the Lake, with an average standing crop of 49 ind. m^{-2}, weighing 13.08 g wet wt. m^{-2} (Table 8.18). Anonymous (1984) recorded 11 species of Mollusca, while Khalil and El-Shabrawy (2002) recorded 12 species (Table 8.19). *Melanoides tuberculata, Theodoxux niloticus* and *Bellamya unicolor* were the most dominant molluscan species (Fig. 8.21).

8.3.1. Other zooplankton components

These are infrequent or rarely recorded and constituted collectively about 1% of total zooplankton. Member of Ciliophora had not been recorded in all seasons except in winter at stations I, II and III, with a peak of 200,000 ind. m^{-3} at station I; they attained an overall average of 7272 ind. m^{-3} forming about 89% of total Protozoa and 0.8% of total zooplankton. Rhizopoda showed no records in most seasons but had been collected from stations I, II, III, IX and X in summer with a highest density of 10000 ind. m^{-3}; they reached to an overall average of 431 ind. m^{-3}, forming 5.3 % of total protozoa and 0.04 % of total zooplankton. *Globigerina* sp. (Foraminifera) was rare in most seasons, but flourished in winter at stations I, II and III, with a highest density of 10000 ind. m^{-3} at station I.

Free living nematodes were recorded in most seasons, with maximum frequency in summer. Stations I, V, VI, VII and VIII showed the highest density and this indicates that they dominated in the eastern and middle part of lake and showed a gradual decrease westwards. Insect larvae had no records in most seasons, but were collected in summer from stations II, III and V, with maximum counts of 2000 ind. m^{-3} and forming an overall average of 113 ind. m^{-3} and 0.01 % of total zooplankton in the lake. *Mysis* sp. was rare in all seasons except in summer, when it had been recorded in all stations, with a highest density of 10000 ind. m^{-3} at station I. Members of Ostracoda were rare in all seasons except in summer, when it was recorded at a moderate density in stations I, VII, VIII, IX, X and XI.

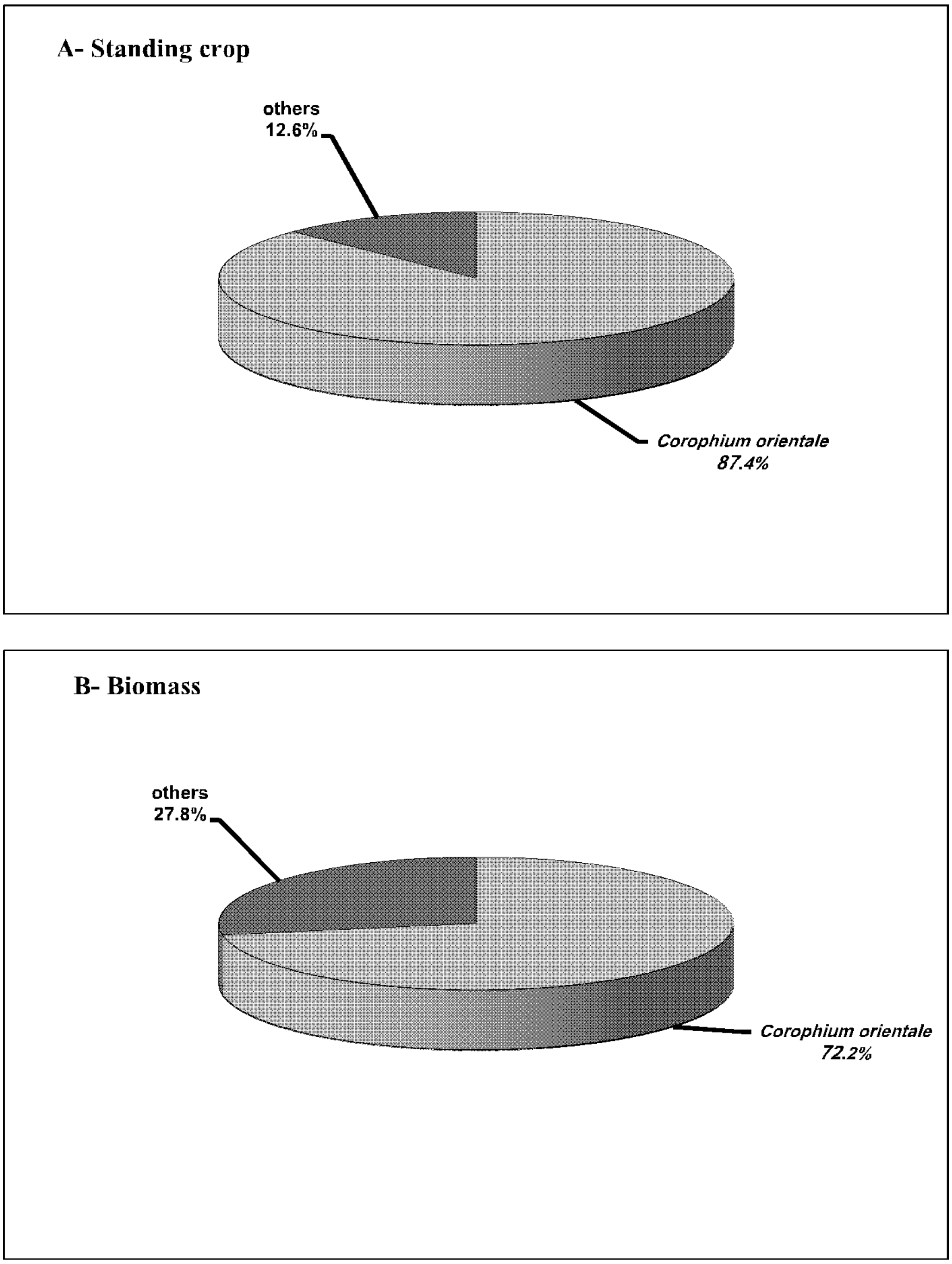


Fig. 8.18. **Community composition of total Arthropoda in 2002.**

Table 8.16 **Standing crop of total Mollusca (ind. m^{-2}) in Lake Burullus during 2001/02.**

Station	Autumn	Winter	Spring	Summer	Average
I	270	180	135	360	**236**
II	405	135	90	45	**169**
III	180	90	360	540	**293**
IV	180	45	45 -	90	**90**
V	**0**	45	45	135	**56**
VI	**0**	**0**	**0**	45	**11**
VII	225	**0**	**0**	450	**169**
VIII	135	90	45	225	**124**
IX	270	90	135	180	**169**
X	225	135	270	315	**146**
XI	+	450	135	720	**435**
Average	**189**	**115**	**115**	**282**	**175**

Table 8.17 **Biomass of total Mollusca (g wet wt. m^{-2}) in Lake Burullus during 2001/02 (after Khalil & El-Shabrawy 2002).**

Station	Autumn	Winter	Spring	Summer	Average
I	88.77	77.23	40.50	143.67	**87.54**
II	40.09	0.67	7.88	1.87	**12.63**
III	57.47	28.22	1.98	27.06	**28.68**
IV	5.50	0.25	20.88	3.46	**7.52**
V	0.00	0.72	0.21	102.60	**25.88**
VI	0.00	0.00	0.00	2.94	**0.74**
VII	0.56	0.00	0.00	28.81	**7.34**
VIII	4.53	0.18	40.80	9.45	**13.74**
IX	10.48	0.72	0.78	10.35	**5.58**
X	21.07	3.67	40.92	10.64	**21.07**
XI	+	17.80	5.16	19.49	**10.61**
Average	**22.85**	**11.77**	**14.46**	**32.76**	**20.46**

8.4. INDICATOR SPECIES

8.4.1. Eutrophication-indicator species

The composition of benthic fauna has long been considered as a good indicator of the water quality because, unlike plankton organisms, they form relatively stable communities in and on the sediments, which integrate changes over long time intervals and reflect characteristics of both sediments and the upper water layer (Samaan *et al.* 1989a).

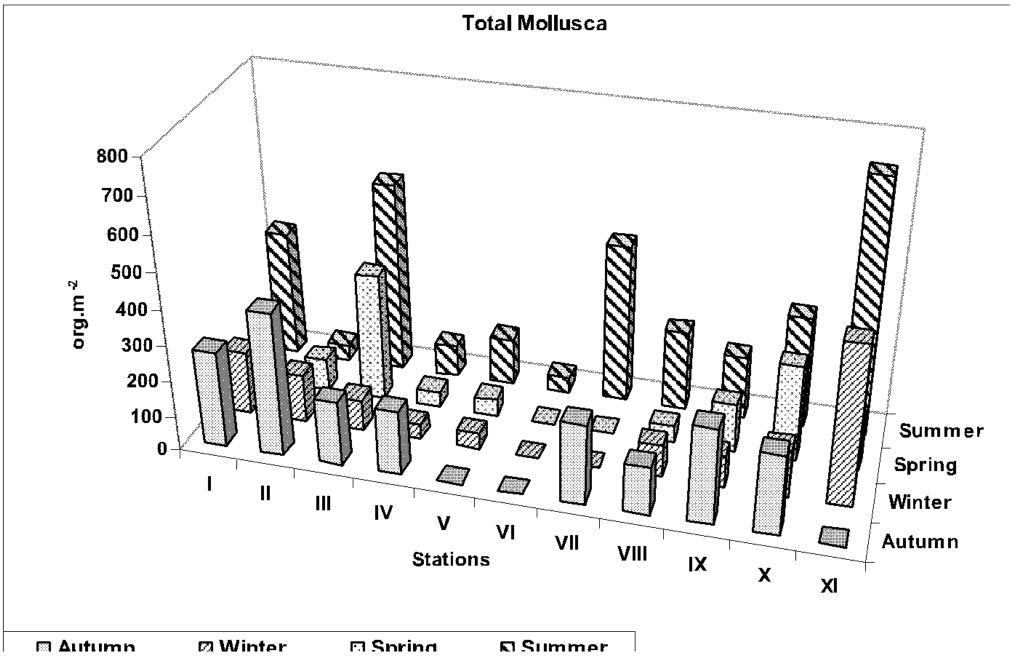


Fig. 8.19. **Standing crop of total mollusca in Lake Burullus during 2001/02.**

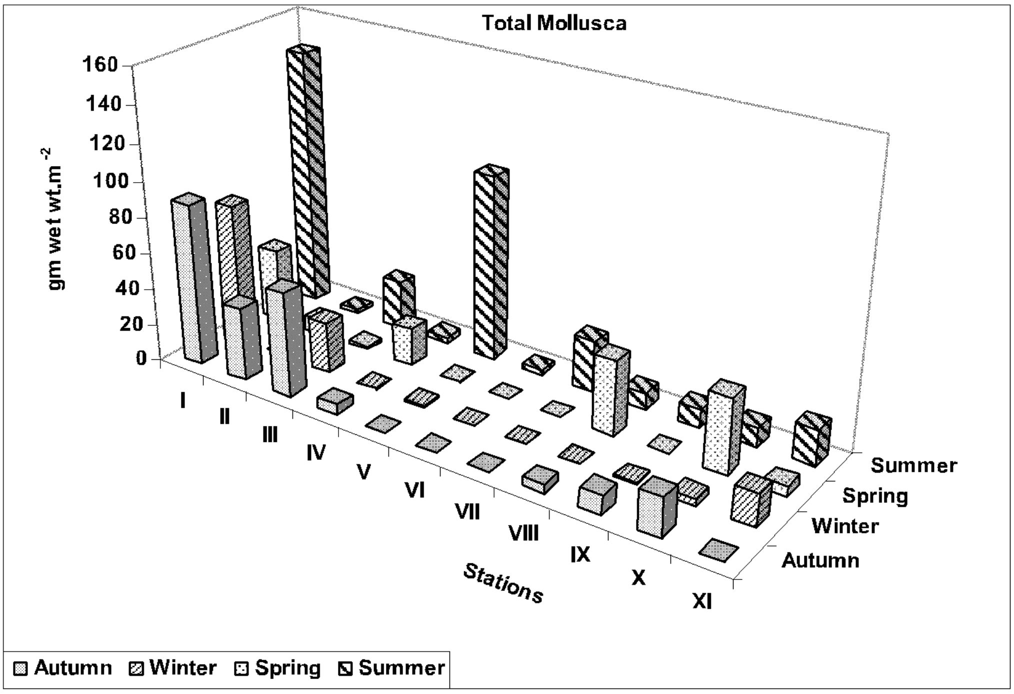


Fig. 8.20. **Biomass of total mollusca in Lake Burullus during 2001/02.**

Table 8.18 **Standing crop (ind. m^{-2}) and biomass (g wet wt.m^{-2}) of different zooplankton groups and their percentage frequency to total benthos during 1978 and 2001/02**

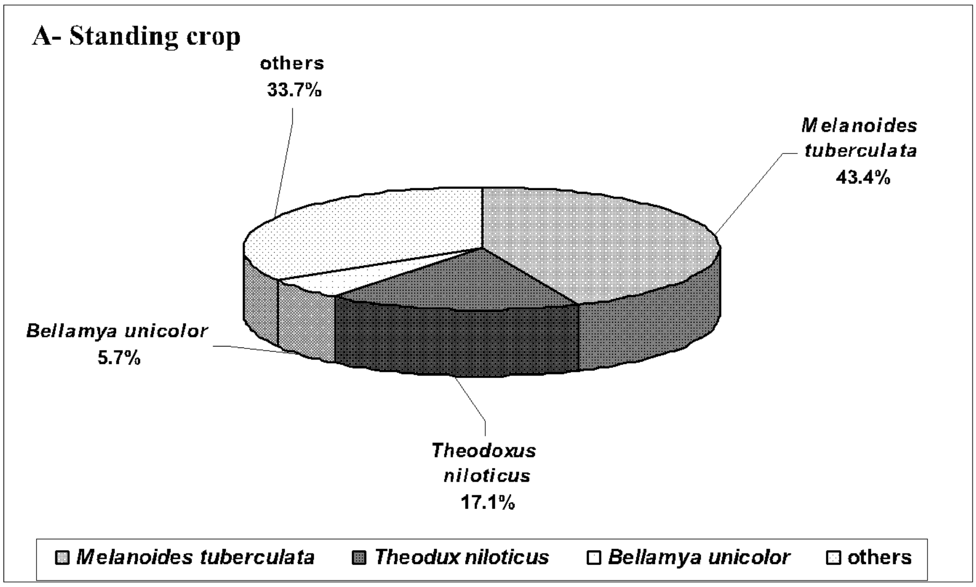
Group	Aboul Ezz (1984)				Khalil & El-Shabrawy (2002)			
	1978				2001 / 2002			
	ind. m^2	%	Wt. m^{-2}	%	ind. m^{-2}	%	Wt. m^{-2}	%
Arthropoda	208	47.3	0.39	2.8	919	33.9	5	16.6
Annelida	183	41.6	0.23	1.7	1613	59.6	3	116
Mollusca	49	11.1	13.08	95.5	175	6.5	20.46	71.8
Total	440	100	13.7	100	2707	100	28.49	100.0

Table 8.19 **Species diversity of benthic groups in Lake Burullus during different periods (1978-2001/02).**

Group	Aboul Ezz (1984)	Anon. (1984)	Khalil & El-Shabrawy (2002)
	1978	1982	2001 /2002
Arthropoda	5	9	13
Annelida	2	4	8
Mollusca	4	11	12
Total	**11**	**24**	**33**

Macrobenthic chironomids were used as indicators of Lake type (trophic state) (Brinkhurst 1971) and macrobenthic oligochaetes (Milbrink 1980; Wiederholm 1980 ; Veronschot 1986) were similarly used. Goodnight & Whitley (1960) used the percentage of oligochaetes in benthic samples to indicate water quality. Brinkhurst (1966 a & b) proposed that the number of tubificids present together with the proportion of *Limnodrilus* to all other species might provide a useful index of organic enrichment. Fingogenova (1996) mentioned that *Limnodrilus hoffmeisteri* and *Aulodrilus japonicus* are eutrophic indicator species that prefer sediment with large amount of allochthonous organic matter. Timm *et al.* (2001) stated that *Limnodrilus hoffmeisteri* is a tolerant species which preferred more eutrophic habitats.

In Lake Burullus, Oligochaeta was represented only by the naidids of *Cheatogaster limnaei* in 1979 (Aboul-Ezz 1984) as a result of a continuous load of nutrient to the lake through the agricultural waste water drains, the eutrophication process increased progressively and became more favorable for the establishment of tubificid oligochaetes species. Six tubificid species dominated mainly by *L. hoffmeisteri* were recorded during 2002. All of these species are considered as indicator of increasing eutrophication of lake Burullus.



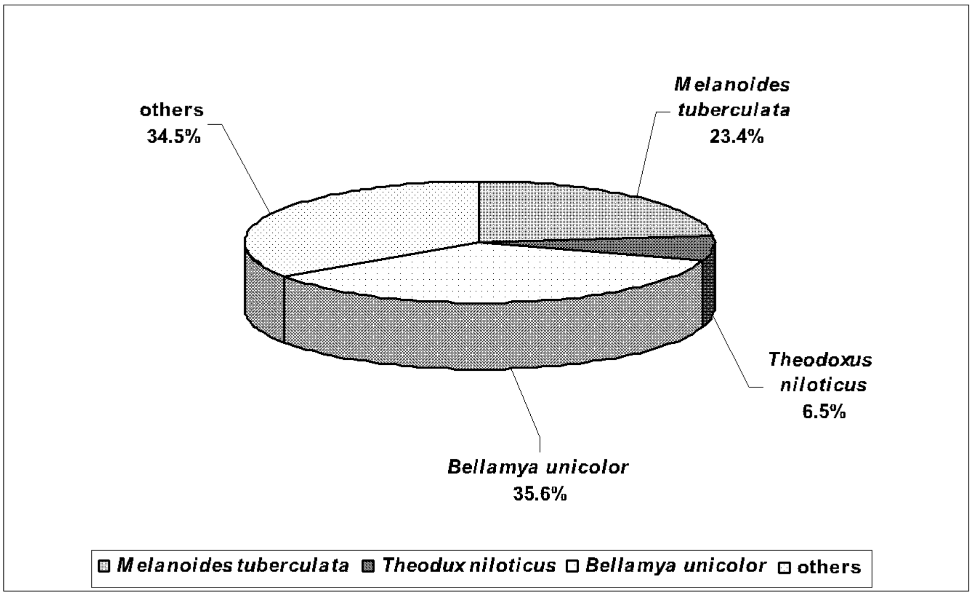


Fig. 8.21 **Community composition of total Mollusca in Lake Burullus (2001/02)**

The gradual increase in fish yield production of Lake Burullus, which is concurrent with increasing benthos and zooplankton standing crop (Figs. 8.22 and 8.23) reflects another sign for the progressive increase of eutrophication of Lake Burullus.

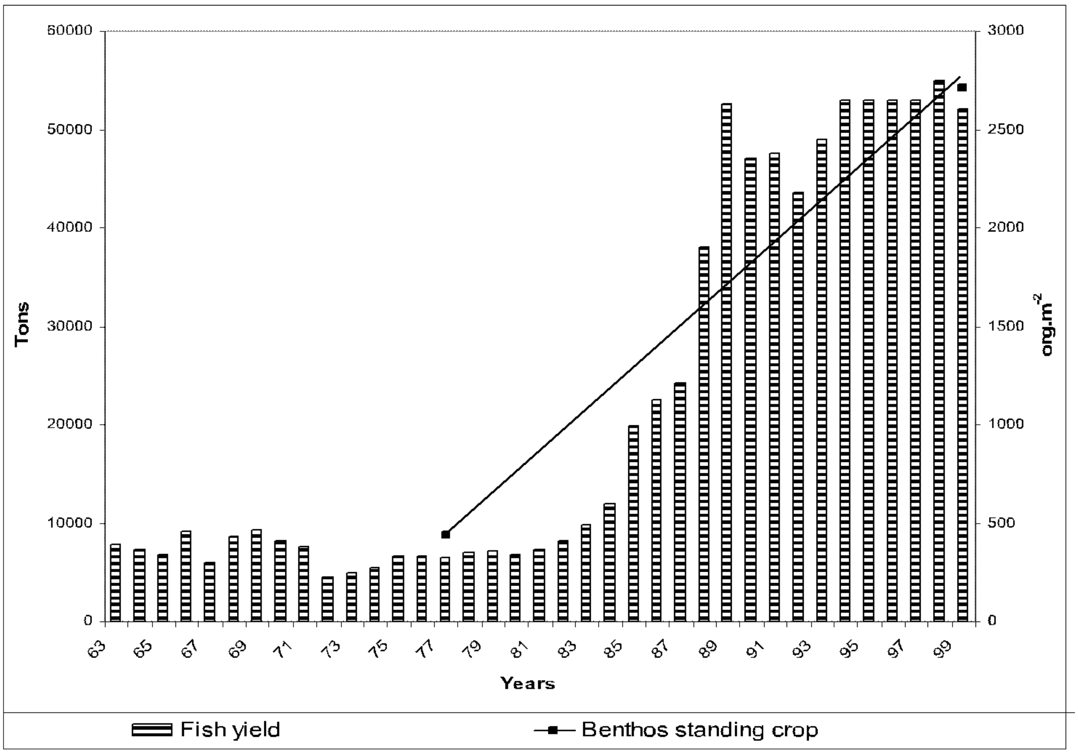


Fig. 8.22 **Fish yield and Benthos standing crop in Lake Burullus during different time intervals 1978 – 2001**

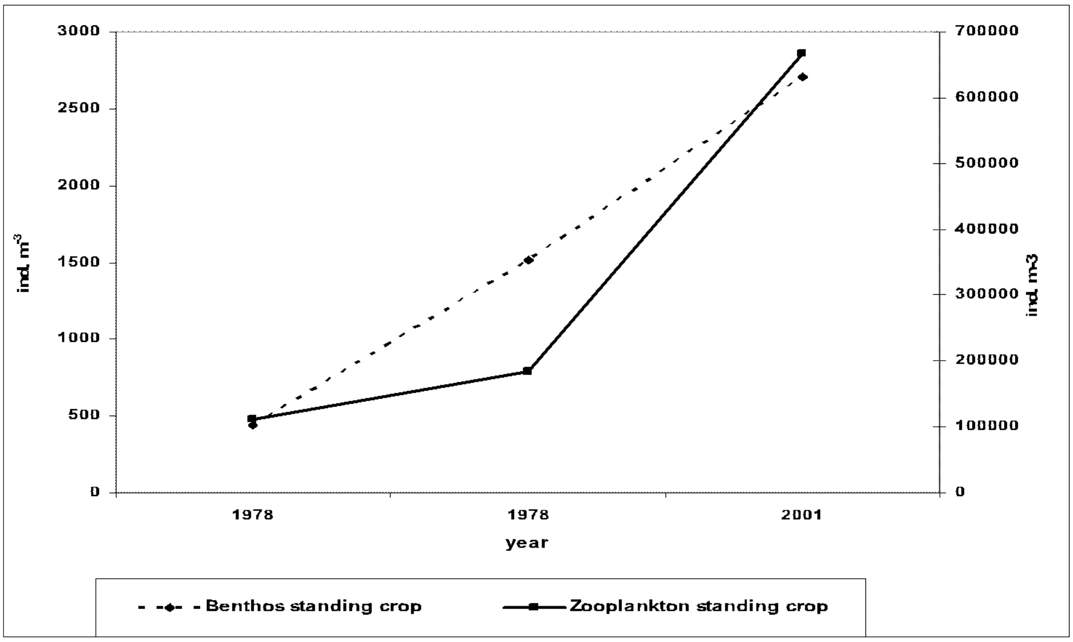


Fig. 8.23 **Zooplankton and Benthos standing crop in Lake Burullus during different time intervals 1978 – 2001**

8.4.2. Salinity-indicator species

The hydrographic condition of Lake Burullus changed since a few years ago (i.e. the amount of agricultural drainage wastewater increased obviously and led to decreasing the water salinity). The total missing of all marine species, previously recorded by Aboul-Ezz (1984) and Anonymous (1984), confirmed this phenomenon. These species are: *Abra ovata, Cerastoderma glaucum, Nassarius cuverii, Cerastoderma edula, Mytilus edulis, Balanus improvisus* and *Ficopomatus enigaticus.* Khalil & El-Dawi (2002) and Bedir (2004) reported the disappearance of both marine zooplankton species and fishes from Lake Burullus during the last decade due to decreasing of salinity.

8.5. SUMMARY

Different studies have revealed that Lake Burullus has become more dulcitude, eutrophic and productive ecosystem, owing to remarkable increase in amount of discharging agricultural drainage, loaded with nutrients, into the lake via the southern drains. Decreasing salinity and nutrients loading have led to a significant influence on biodiversity and abundance of benthos in Lake Burullus. The benthic communities are still subject to the evolutionary trend towards progressive dulcification and eutrophication promoting species, that prefer eutrophic habitats (tubificids and gastropods), which concurrently goes with disappearing of marine species.

Thirty three macrobenthic species, belonging to three main groups (Arthropoda, Annelida and Mollusca) were recorded in the Lake during 2002. There was no sign of occurrence of 8 marine species, which have been previously recorded in the Lake during the seventies and eighties of the last century. On the other hand, 17 species (freshwater in origin) were recorded for the first time in Lake Burullus during 2002.

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8.7. PLATES OF MACROBENTHOS (8.1 – 8.5)

(after Fishar 1995; Ibrahim *et al.* 1999)

Plate 8.1
Branchiura sowerbyi
Limnodrilus hoffmeisteri
Limnodrilus udekemianus
Helobdella conifera

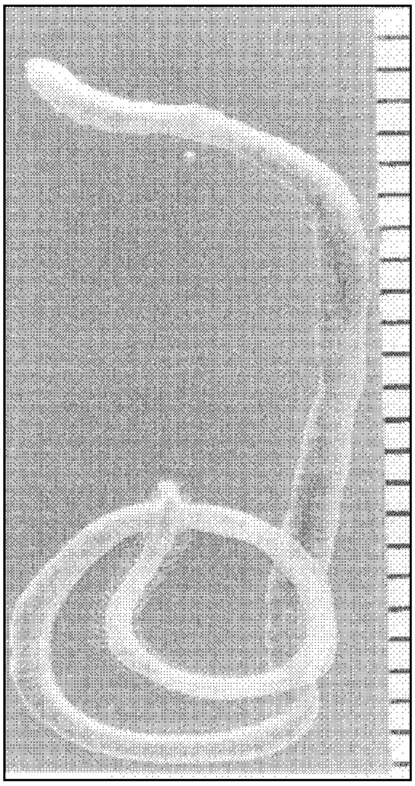
Plate 8.2
Nymph of *Ischneura* sp.
Micronecta plicata
Nymph of *Neurocordula* sp.

Plate 8.3
Physa acuta
Bellamya unicolor
Lanistes carinatus
Theodoxus (Neritaea) niloticus

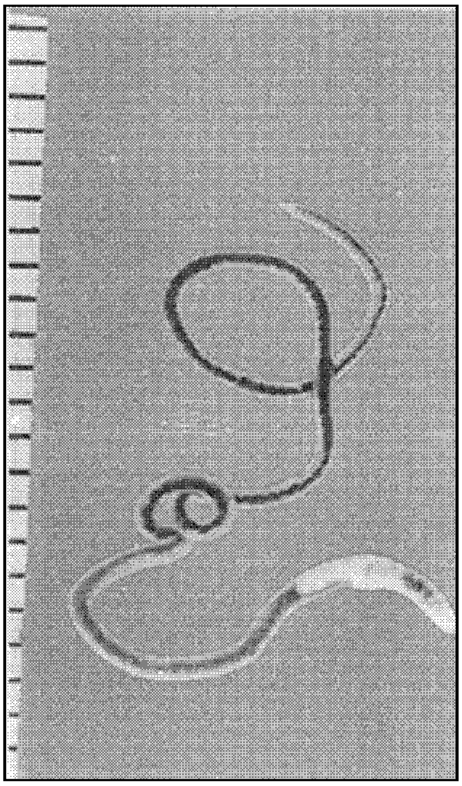
Plate 8.4
Succinea cleopatra
Gyraulus ehrenbergi
Melanoides tuberculata
Cleopatra bulimoides

Plate 8.5
Biomphalaria alexandrina
Bulinus truncatus
Corbicula consobrina

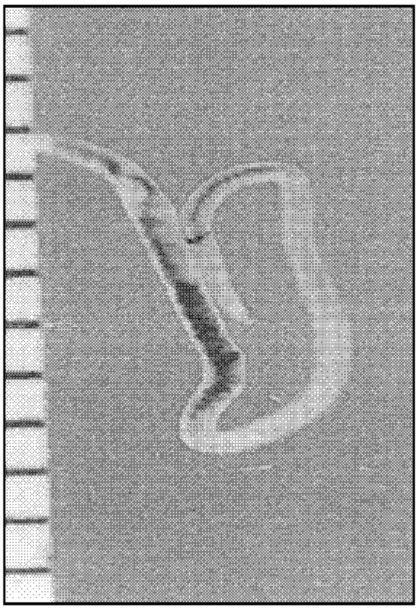
Plate 8.1



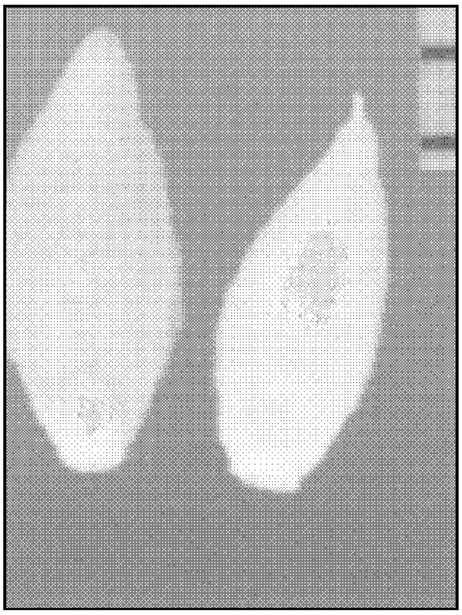
Branchiura sowerbyi



Limnodrilus udekemianus

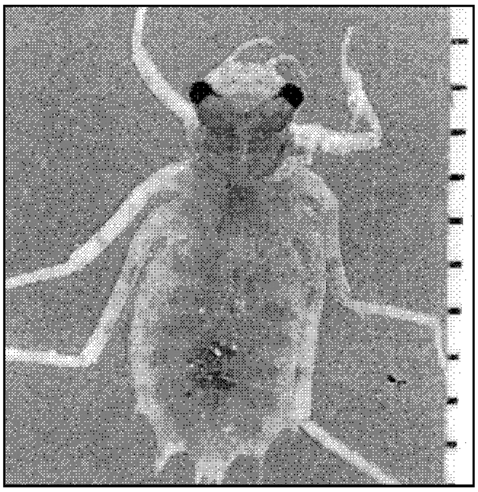


Limnodrilus hoffmeisteri

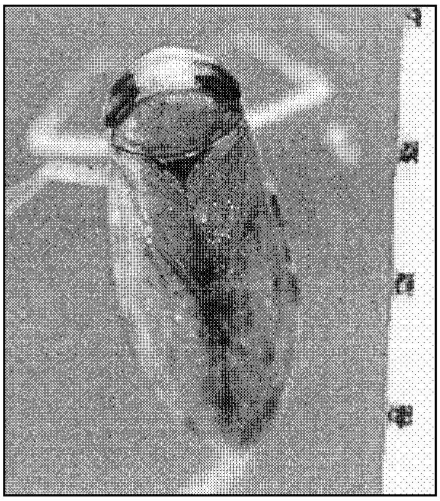


Helobdella conifera

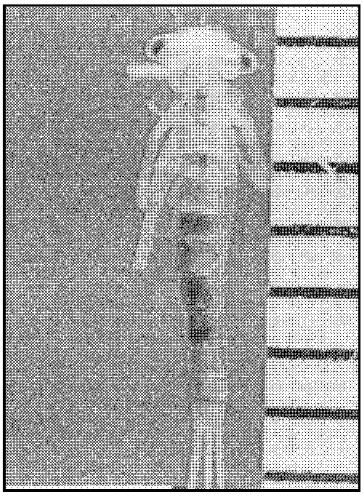
Plate 8.2



Nymph of *Ischneura* sp.

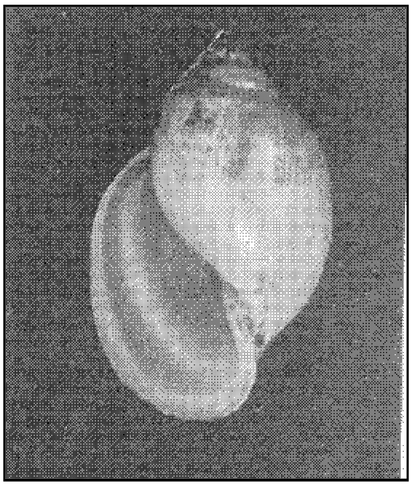


Micronecta plicata

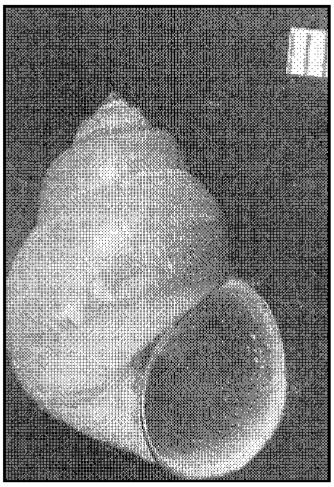


Nymph of *Neurocordula* sp.

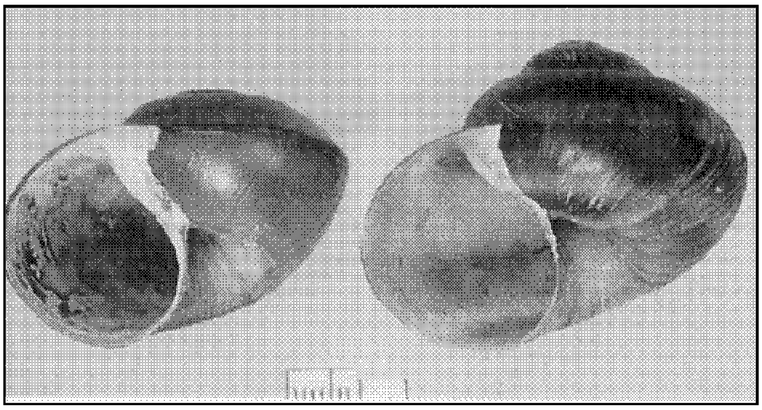
Plate 8.3



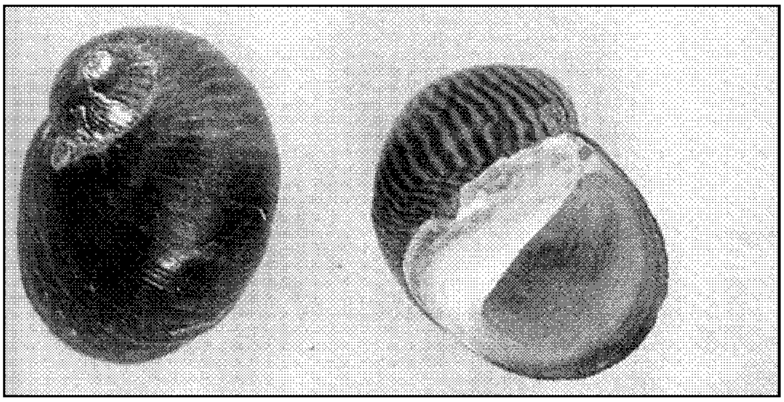
Physa acuta



Bellamya unicolor

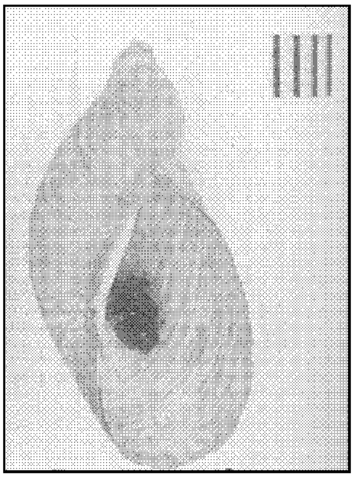


Lanistes carinatus

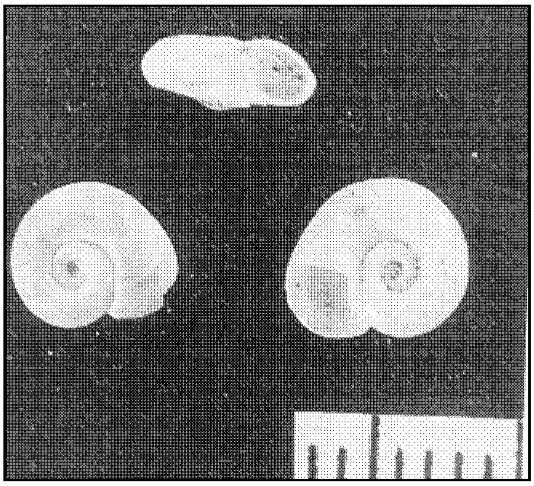


Theodoxus (Neritaea) niloticus

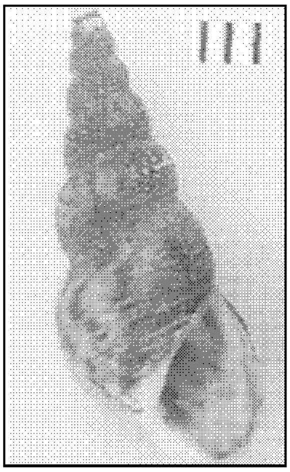
Plate 8.4



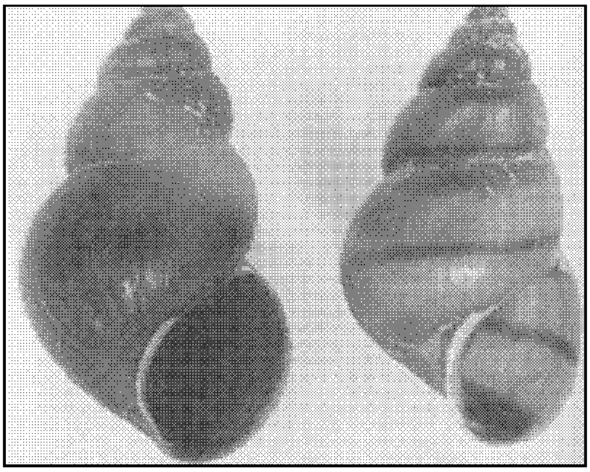
Succinea cleopatra



Gyraulus ehrenbergi

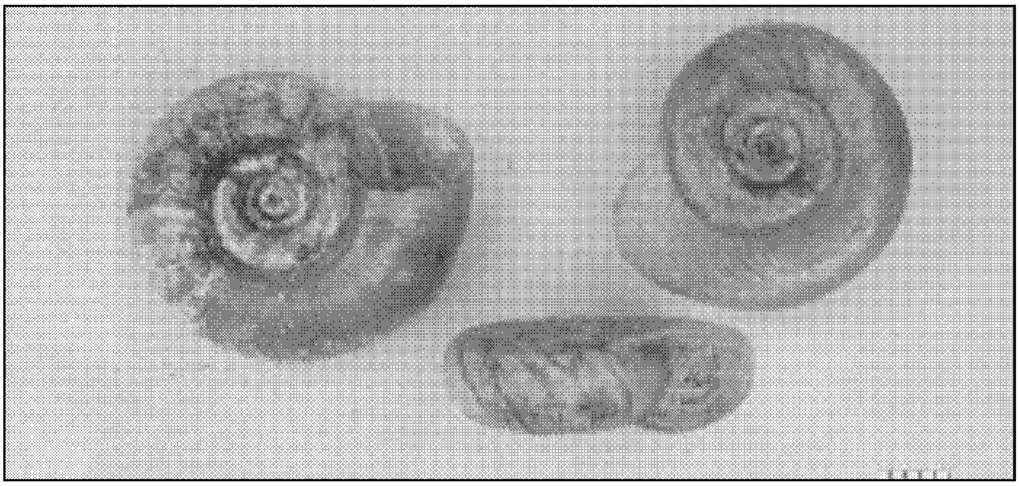


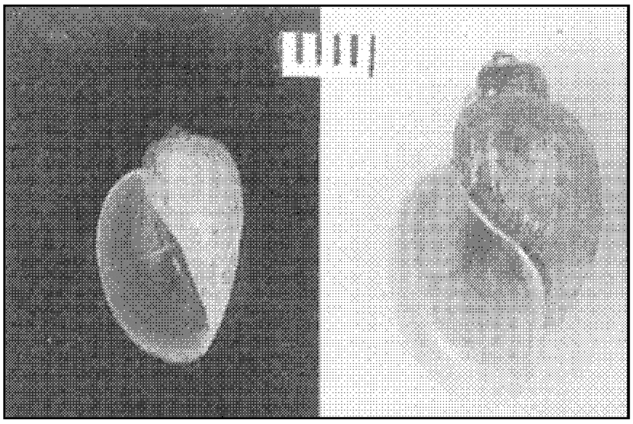
Melanoides tuberculata

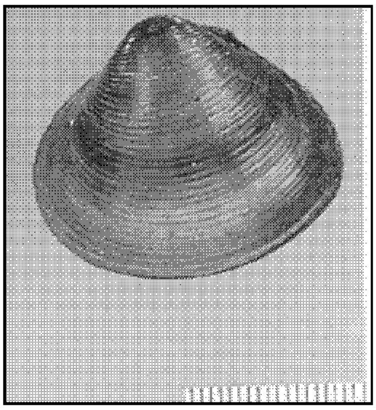


Cleopatra bulimoides

Plate 8.5


Biomphalaria alexandrina


Bulinus truncatus


Carbicula consobrina

Chapter 9
Fishes and Fisheries

9.1. SPECIES COMPOSITION

The occurrence of brackish and saline waters in Lake Burullus resulted in a large variety of fish species inhabiting the Lake during the seventies and early eighties of the last century. Approximately 32 species were recorded in the Lake during these periods (Libosvarsky *et al.* 1971; El-Sedfy 1971). Table 9.1 includes both freshwater and marine species arranged according to their systematic relevance.

The fish stock consisted of a variety of fishes differing in their requirements to saline water. Thus, several pure marine species, such as *Engraulis encrasicholus. Belone belone, Sparus aurata, Johnius hololepidotus, Pomatoschistus minutus* and *Solea solea* invade the Lake for some time along with the halophilous species of mullets (*Chelon labrosus, Liza aurata and L. saliens*). Broader distribution in the brackish water includes *Aphanius fasciatus, Atherina mochon*, while other representatives of family Gobiidae. *Anguilla anguilla, Mugil cephalus* and *Liza ramada* belong to a separate group of obligatory migrants. In the life history of these species, two phases have been differentiated; where spawning occurs in the sea, then the young individuals migrate into the Lake to continue their growth till adult stage is attained, then migrate to the sea to spawn.

Some Nile fishes inhabit the lake, such as *Hydrocynus forskalii, Labeo niloticus, Barbus bynni, Barbus perince, Clarias gariepinus, Bagrus bajad, Lates niloticus* as well as the cichlids belonging to five genera namely: *Hemichromis, Haplochromis, Tilapia, Oreochromis and Sarotherodon.*

Tilapia zillii is widely distributed in the Lake on account of its high tolerance to saline water; while *Oreochromis niloticus* was the second common species of cichlids. *Sarotherodon galilaeus* as well as another cichlid,

Hemichromis bimaculatus, avoid salty water. Their occurrence was restricted to areas of low chlorosity. *Mugil cephalus* and *Liza ramada* are spread out all over the lake. The introduced species *Gambusia affinis* shows a similar wide distribution.

Table 9.1. **Fish species in Lake Burullus.**

Family	Species	Arabic name	Habitat
Engraulidae	*Engraulis encrasicholus* (Linnaeus, 1758)	انشوجة	Sea water
Characidae	*Hydrocynus forskalii* (Cuvier, 1819)	كلب السمك	Fresh water
Cyprinidae	*Labeo niloitcus* (Forskal, 1775)	لبيس نيلى	Fresh water
	Barbus bynni(Forskal,1775)	بنى أصلى	Fresh water
	Barbus perince Ruppell 1837	بنى برنس	Fresh water
Siluridae	*Clarias gariepinus* (Burchell,1822)	حوت	Fresh water
	Bagrus bajad (Forskal , 1775)	بياض	Fresh water
Anguillidae	*Anguilla anguilla* (Linnaueus, 1758)	حنش	Fresh / saline water
Belonidae	*Belone belone* (Linnaeus, 1758)	خرم	Saline water
Cyprinodontidae	*Aphanius fasciatus* (Valenciennes, 1821)	بطريق	Brackish water
Poecilidae	*Gambusia affinis* (Baird & Girard , 1853)	جامبوزيا	Brackish water
Atherirudae	*Atherina mochon* Cuvier, 1829	بساريا	Brackish water
Mugilidae	*Mugil cephalus* Linnaeus, 1758	بورى	Fresh / saline water
	Liza ramada (Risso, 1826)	طوبارة	Fresh / saline water
	Liza aurata (Risso,1810)	هليلى-دهبانة	Saline water
	Liza saliens (Risso,1810)	جران	Saline water
	Chelon labrosus (Cuvier, 1829)	بورى سودانى	Saline water
Serranidae	*Lates niloticus* (Linnaeus, 1762)	قشر بياض	Fresh water
	Dicentrarchus labrax (Linnaeus, 1758)	قاروص	Saline water
	D. punctatus (Bloch, 1792)	قاروص منقط	Saline water
Cichlidae	*Hemichromis bimaculatus* Gill , 1862	هيمكروس مخطط	Fresh water
	Haplochromis bloyeti (Sauvage,1883)	هابلوكروس قزم	Fresh water
	Tilapia zillii (Gervais, 1848)	بلطى اخضر	Fresh / saline water
	Oreochromis niloticus (L.,1757)	بلطى نيلى	Fresh water
	Oreochromis aureus (Steindachner,1864)	بلطى ازرق	Fresh water
	Sarotherodon galilaeus (Artedi,1757)	بلطى جليلى	Fresh water
Sparidae	*Sparus aurata* Linnaeus, 1758	دنيس	Saline water
Sciaenidae	*Lohnius hololepidotus* (Lacepede, 1803)		Saline water
Gobiidae	*Pomatoschistus minutus* (Pallas ,1767)	ابو كرش	Brackish water
	Pomatoschistus (Iliinia) microps (Krover [illegible]		Brackish water
	Lesueuria lesueuri (Risso,1810)	ابو كرش	Brackish water
Soleidae	*Solea solea* (Linnaeus,1758)	موسى	Saline water

The largest number of fish species were caught at the lake side of El-Boughaz opening. 21 species were sampled at that locality (Libosvarsky, *et al.* 1971). The collection consisted of a blend of marine as well as freshwater and euryhaline fishes. Also, the area at the mouth of Nasser drain was found to be rich in fish species, 17 species were recorded at that site. Pure marine fishes were absent from that locality; they were replaced by fishes of Nile origin, such as *Hydrocynus forskalii, Labeo niloticus, Barbus bynni* and *Lates niloticus.* The number of fish species captured in the remaining localities shows low frequency. This phenomenon, rather peculiar in faunisitic surveys, is associated with the different ranges of requirements of the species towards the salinity of water.

9.1.1. Present status of fish species

During 2000 – 2002 period, the field survey of Khalil and El-Dawy (2002) showed that the diversity of fishes in Lake Burullus declined from 32 species to 25 ones. All species which have disappeared from the lake are of marine origin, these are: *Engraulis encrasicholus*, *Belone belone*, *Pomatoschistus minutus*, *Pomatoschistus (Iljinia) microp*, *Lesueuria lesueuri*, *Liza aurata* and *Chelon labrosus*.

9.2. FISH PRODUCTION

The total fish production of Lake Burullus for the years 1963 to 2003 is shown in Table 9.2, Fig. 9.1. Following different years of the survey, it is seen that the total production of the lake increased gradually from 7349 ton in 1963 to a maximum of 59000 ton in 2002. In the course of these fourty years a sharp decline in the total yield was recorded, especially in the mid seventies of the last century, where the production declined to 4556 and 4875 ton in 1973 and 1974, respectively. Higher yields were regained in 1976 (6573 ton).

As far as the main groups of fishes are concerned, a gradual decline in the mullets catch was recorded in 2000 from about 44.7% in 1963 to 17% of the total catch. This was accompanied by an increase of tilapia production from 42.8% in 1963 to 72% in 1992, then decreased to about 67.8% in 2003. The shift was more pronounced during the eighties of the last century. On the other hand, the annual production of certain freshwater fish species has gradually increased, especially during the last five years. This relates particularly to two species namely: *Clarias gariepinus* and *Bagrus bajad*, where their production increased from 188 and 220 ton in 1963 to 2150 and 744 ton in 2003, respectively (GAFRD 2003). Meanwhile, the production of marine fishes, such as *Johnius hololepidotus* and *Dicenlrarchus labrax* greatly decreased.

Table 9.2. **Fish production of Lake Burullus from 1963 to 2003.**

Year	Total production (Ton)	Year	Total production (Ton)
1963	7549	**1984**	9854
1964	7796	**1985**	11947
1965	7242	**1986**	19908
1966	6769	**1987**	22510
1967	9149	**1988**	24274
1968	6002	**1989**	38070
1969	8597	**1990**	52520
1970	9257	**1991**	47068
1971	8236	**1992**	47501
1972	7497	**1993**	43620
1973	4556	**1994**	49000
1974	4875	**1995**	53000
1975	5469	**1996**	53000
1976	6573	**1997**	53000
1977	6587	**1998**	53000
1978	6514	**1999**	55000
1979	7018	**2000**	52000
1980	7137	**2001**	59200
1981	6742	**2002**	59785
1982	7273	**2003**	55323
1983	8205		

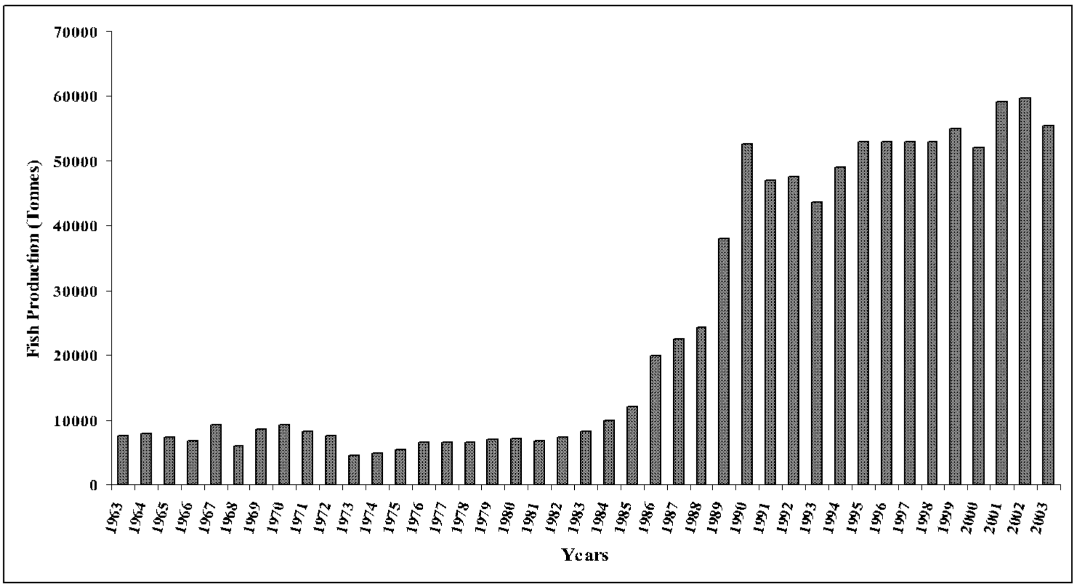


Fig. 9.1. **Fish production of Lake Burullus from 1963 to 2003.**

All these findings confirm a pronounced predominance of freshwater components in the fish stock of the lake, reflecting the changes that took place in the lake in the water supply, mostly from drains, and reducing chlorosity of water, specially in the eastern part of the lake, in association with the new huge drains constructed at that area.

9.3. FISHERIES OF LAKE BURULLUS

9.3.1 Biology of Cichlidae

Cichlids are represented in Lake Burullus by four main species which are *Tilapia zillii, Sarotherodon galilaeus*, *Oreochromis niloticus* and *O. aureus*, in addition to two species of cichlids (*Hemichromis bimaculatus* and *Haplochromis bloyeti*) that are of little economic importance due to their small sizes.

9.3.1.1. Abundance of different cichlid species in Lake Burullus

The catch per unit effort (CPUE) of trammel nets left over-night (Table 9.3) shows that T. zillii is the most abundant cichlid, followed by O. aureus, S. galilaeus, then O. niloticus. This method is usually set near the vegetated areas, which are the most preferable feeding zones for T. zillii (Al-Kholy & Abdel-Malek 1972), while the CPUE of trammel nets using a sound stimulus showed that S. galilaeus dominates the catch followed by O. aureus and O. niloticus (Table 9.3).

Table 9.3. **Catch per unit effort of different fishing gears according to fish species in Lake Burullus.**

Species	Trammel nets without stimulus			Trammel nets with stimulus			**Wire traps (Gawabi)**		
	No.	**Wt (g)**	**Wt (%)**	**No.**	**Wt (g)**	**Wt (%)**	**No.**	**Wt (g)**	**Wt (%)**
Tilapia zillii	29	1196	3	2	82	2	4	1708	12
Sarotherodon galilaeus	10	354	11	45	1747	50	166	4831	33
Oreochromis niloticus	7	350	11	7	401	12	62	2808	19
Oreochromis aureus	13	618	18	23	1027	29	88	3t35	22
Mugil cephalus	1	33	1	-	-	-	-	-	-
Liza ramada	3	91	2	-	-	-	-	-	-
Hemichromis bimaculatus	42	556	17	-	-	-	-	-	-
Catfishes	2	128	4	-	-	-	-	-	-
Other fish species	1	13	-	1	229	7	5	2114	14

The abundance of *S. galilaeus* in the catch of wire traps may be due to its bigger body girth. In addition, the paucity of *T. zillii* in the catch of wire traps and its dominance in the catch of trammel nets may be attributed to its relatively small sizes and the use of nets with small mesh sizes than that of wire traps

9.3.1.2. Seasonal variations of cichlid species in the catch

Investigation of seasonal variation of the cichlid species in the catch shows that spring and summer are the proper time for fishing cichlids with trammel net left over-night. This is because cichlid species are more active during warm seasons, in addition that most fishermen are accustomed to use other fishing gears and techniques for catching mullet species during autumn and winter months. *T. zillii* is the most abundant species in the catch during spring followed by *O. aureus* and *S. galilaeus* then *O. niloticus*, while in summer *Haplochromis bimaculatus* is the most abundant species followed by *T. zillii*, then *O. niloticus*, *O. aureus* and *S. galilaeus*. In autumn, *O. niloticus* is the most abundant species followed by *S. galilaeus* and *O. aureus*, while *T. zillii* is rare. In winter, *T. zillii* is the most abundant, followed by *O aureus*, then *S. galilaeus*, while *O. niloticus* is rare.

In the catch of trammel nets with sound stimulus, *O. aureus* was found to be a dominant species during winter. This may be due to its greater activity than other cichlid species during that season. In spring, *O. niloticus* is abundant only by weight, while *S. galilaeus* is dominant by number. Furthermore, *S. galilaeus* is dominant in summer and autumn, indicating that it shows more response to sound stimulus. *O. niloticus* and *O. aureus* come next in order of abundance.

For wire traps in winter, the catch is generally very poor and this could be attributed to the low water temperature that prevails in the lake, especially in areas of dense vegetation, where traps are usually set. The four tilapia species are more or less of equal abundance in the catch, however, they can be arranged as follows: *T. zillii* has relatively more abundance, followed by *S. galilaeus* and *O. aureus*, then *O. niloticus*. In spring, *S. galilaeus* and *O. aureus* are represented by the same percentage in the catch, followed by *T. zillii* then *O. niloticus*. In summer and autumn, *S. galilaeus* is the most abundant species in the catch, followed by *O. niloticus* and *S. aureus*, while *T. zillii* is less abundant.

9.3.1.3. Length frequency of cichlids using various fishing gears

Analysis of length frequency of *T. zillii* in the catch of trammel nets, shows fish as small as 5 cm in total length (TL), while the largest fish has a maximum size of 21 cm, with a modal length of 10 cm (Hashem *et al.* 1993). Small-sized fishes (<10 cm TL) represent 47% of the catch and medium-sized fishes (11-15 cm TL) represent 49%, while larger fishes (>*15* cm TL) represent only 4% of the catch. This disagrees with the finding of Ishak *et al.* (1985), who

pointed out that about 90% of the catch of *T. zillii* caught from Lake Burullus were less than 10 cm.

In the catch of wire traps, the minimum size of *T. zillii* is 7 cm and the maximum size is 24 cm, with a modal length at 13 cm. Medium-sized fishes (11-15 cm TL) are the most abundant, representing 80% of the trap catch. This must be due to the smaller mesh size used in trammel nets, while traps have larger mesh size (Hashem *et al.* 1993).

S. galilaeus in the catch of trammel nets is composed of fishes ranging from 6-23 cm (TL) with a modal length at 14 cm. The small-sized fishes (<10 cm TL) represent only *5%,* and the medium-sized fishes (10-15 cm TL) represent 85 %, while larger fishes (16-20 cm TL) represent only 10 % of the catch. For wire traps, the range of total length is from 5-17 cm (TL) with a modal length at 12 cm. Most of the catch (85%) were of medium-sized fishes (11-15 cm), while small fishes represent 9%, and large fishes 6% of the catch.

O. niloticus in the catch of trammel nets is composed of fishes ranging from 8-27 cm (TL) with a modal length at 16 cm. Small fishes (<10 cm TL) represent only 8%, while the medium-sized and large fishes (11-15 cm, and 16-20 cm TL) are the most abundant.

Efficiency of various fishing gears for different species shows percentage composition of length groups for tilapia species in Lake Burullus.

For the wire traps, the maximum size is 37 cm with a modal length of 16 cm. Medium-sized fishes represent 42% of the catch, while large fishes (>16 cm) are most abundant (55% of the catch).

O. aureus caught by trammel nets has a minimum size of 7 cm (TL), while the maximum is 19 cm and the modal length at 13 cm. The small fishes (<10 cm) represent 6% of the catch, while medium sizes (10-15 cm) are the most abundant fishes in the catch (80% of the catch), and the large fish represent 14% of the catch.

For wire traps, the length range of fishes is 7-19 cm with a modal length at 13 cm. The medium-sized fishes (11-15 cm) are dominant in the catch (87% of the total catch), while large fishes (>16 cm) represent 15% of the catch.

Analysis of the efficiency of various fishing gears for catching tilapia species shows that traps are more efficient for catching *T. zillii* than trammel nets, while the efficiency of both gears are nearly similar for the other tilapia species. Furthermore, a high percentage of the catch of *T. zillii* and *O. aureus* is composed of medium sized fish (11-15 cm).

Many authors such as El-Zarka *et al.* (1970) and Moussa (2003) pointed out that the fishery management of cichlid species must be based on the criterion

of gaining extra fish weight, because the mean size of cichlid species in the catch of the northern Delta lakes does not affect their breeding activities, i.e. first maturity is usually attained at small sizes. By this procedure, the total catch of cichlid species from the lake is expected to increase a rather two or three times than that available today. These authors suggested that the most effective methods to attain such a gain were the regulation of the mesh of the fishing gears. Thus, Hosny & Hashem (1993) recommended that the stretched mesh size of the trammel nets should not be less than 2.86 cm (or mesh number 17) to catch cichlid fishes of mean selection length of 12.0 cm. However, El-Zarka (1961) as well as Ishak *et al.* (1985) recommended trammel nets with the same mesh 17 to catch fishes of about 15 cm for either *O. niloticus* or *T. zillii*. For traps, El-Zarka *et al.* (1970) suggested that the mesh size of wire traps should not be less than 25 mm (mesh bar) to give a mean selection length of 16 cm for *O. niloticus,*15.5 cm for *T. zillii* and 15 cm for *S. galilaeus*.

From the above findings, it is recommended that the minimum catcheable size should be 15 cm, instead of the present legal size (10 cm). Consequently, this will increase the average weight of individual fish from 10 to 60 gm and hence the total fish yield will be increased.

9.3.1.4. Mortality and survival rates

T. zillii has the lowest mortality rates (i.e. 0.646, 0.899 and 1.545 for natural, fishing and total mortality rates, respectively) (Table 9.4). *S. galilaeus* and *O. niloticus* rank next having more or less equal mortality rates (about 0.7, 1.3 and 2.1 for natural, fishing and total mortality rates, respectively). Meanwhile, *O. aureus* has the highest mortality rates (i.e. 0.868, 2.119 and 2.987 for natural, fishing and total mortality rates, respectively). It has to be mentioned that for *O. niloticus*, the highest survival rate occurs after the second year, while for the other three species it is after the first year (Hashem *et al.* 1993). This means that *T. zillii* would have the highest survival rate, i.e. about 21%, followed by *O. nilolicus* and *S. galilaeus* (each about 13%), while *O. aureus* has the lowest survival rate (about 5% from the population annually).

The high mortality rates and consequently the lower survival rates of the four cichlid species in Lake Burullus indicate that cichlid fishes in the lake suffer from annual decline in the stock.

The exploitation rates were estimated for the four cichlid species in the lake (Table 9.5) by Hashem *et al.* (1993), where *O. aureus* was the most exploited cichlid species (E = 0.71) followed by *O. niloticus* and *S. galilaeus* (E = 0.63) and at last *T. zillii* (E = 0.58). It seems that the increase of the exploitation rate of cichlid species in Lake Burullus would increase the yield per recruit, but the biomass of these species will show an annual decrease in the Lake. Therefore, it is highly recommended to reduce the effort exerted on the

cichlid populations in Lake Burullus, since higher effort would eventually severely deteriorate their biomass.

Table 9.4. **Mortality and survival rates for the different cichlid species in Lake Burullus (Hashem *et al.* 1993).**

Species	Mortality			Survival (%)
	Natural	Fishing	Total	
Tilapia zillii	0.646	0.899	1.545	21.3
Sarotherodon galilaeus	0.771	1.301	2.072	12.6
Oreochromis niloticus	0.764	1.291	2.055	12.8
Oreochromis aureus	0.868	2.119	2.9S9	5.0

Table 9.5. **Exploitation rate (E), yield per recruit (Y/R) and biomass per recruit (B/R) for different cichlid species in Lake Burullus (at predicted maximum yield per recruit) (Hashem *et al.* 1993).**

Species	Present situation			At maximum Y/R		
	E	Y/R	B/R	E	Y/R	B/R
Tilapia zillii	0.58	0.016	0.320	0.65	0.016	0.164
Sarotherodon galilaeus	0.63	0.021	0.231	0.85	0.032	0.073
Oreochromis niloticus	0.63	0.034	0.316	0.75	0.035	0.124
Oreochromis aureus	0.71	0.026	0.159	0.80	0.026	0.099

The recruitment patterns of cichlid species in Lake Burullus show that the new recruits enter the exploited population during almost all the year round. The recruits of *T. zillii* have two peaks, the first during November and December (44%), while the second in May (37%). For *S. galilaeus*, there are two recruits, a pronounced one during December and January (41%), and a lesser in October (28%). *O. niloticus* on the other hand, has a peculiar pattern in its recruitment, it shows two groups of recruit with a wide overlap in their timing, extending from August to January with two peaks; a high one in September (59%) and a low peak in December (26%). For *O. aureus*, the recruitment pattern involves a prolonged period from September to June with two peaks; the higher one in March (72%) and the low in September (16%) (Hashem *et al.* 1993).

On the other hand, one of the most detrimental fishing method to the fishery of the lake (especially cichlid fishery) is the "Hosha" system (see 9.3.5.9 for definition of this fishing method). However, MacLaren (1981) stated that

Hosha may play an important beneficial role in reducing juvenile cichlid stock in the lake. While the construction and operation of "Hosha" in Lake Burullus is illegal, its number increases every year (under the name of fish culture ponds). Therefore, "Hosha" system needs a thorough evaluation on the basis of which, proper regulations should be enforced.

Moussa (2003) found that *Oreochromis niloticus* was the most abundant species in the 2002 catch, constituting more than 40.49 % of the total catch, followed by *Oreochromis aureus* 34.74 %, while *Sarotherodon galilaeus* was the least frequent species, contributing 24.77 %. In the eastern region, *Oreochromis aureus* is the most common one (38.48 %) followed by *Sarotherodon galilaeus* (31.45 %), then *Oreochromis niloticus* (30.08 %). In the middle and western region *Oreochromis niloticus* is the major one with 39.78% and 53.62 %, respectively. *Oreochromis aureus* represents 35.69 and 28.88 %, whereas *Sarotherodon galilaeus* is the minor one with 24.53 and 17.49 % in the two regions, respectively (Table 9.6).

Table 9.6. **Species composition of cichlid fish species (ind catch $^{-1}$) collected from three regions of Lake Burullus during 2002 (Moussa 2003).**

Species	Sector						Total	%
	Eastern		Middle		Western			
	Actual	%	Actual	%	Actual	%		
Oreochromis niloticus	351	30.08	467	39.78	518	53.62	1332	40.49
Oreochromis aureus	449	38.48	419	35.69	279	28.88	1143	34.74
Sarotherodon galilaeus	367	31.45	288	24.53	169	17.49	815	24.77
Total	**1167**	-	**1174**	-	**966**	-	**3290**	**100**

9.3.1.5. The length-weight relationship

The relation between the length and weight of a fish represents one of the most studied biological characters of fish biology. It is known that the weight of a fish increases as a function of its length. Length-weight relationship is an essential biological parameter needed to appreciate the suitability of the environment for any fish. Moussa (2003) calculated the length-weight relationship by the general formula $W = a L^n$. This equation from which weights were derived to show the different degrees of deviation from the cube relationship between weight and length. The logarithmic form of this equation which is actually used in calculation of weights in Tables (9.7, 9.8 and 9.9) can be written as follows: $\log W = \log a + n \log L$. The computed equations

representing the relation between length and weight for the mentioned fish species in the three sectors can be presented as follows:

For *Oreochromis niloticus:*

Eastern sector (Fig. 9.2.a): $W = 0.0163\ L^{2.8944}$ ($R^2 = 0.997$)
Middle sector (Fig. 9.2.b): $W = 0.0139\ L^{3.0042}$ ($R^2 = 0.995$)
Western sector (Fig. 9.2.c): $W = 0.0091\ L^{3.2940}$ ($R^2 = 0.991$)

***Table 9.7.* Mean total length (Mtl: cm), emperical weight (Mew: g) and calculated weight (Mcw: g) for different length groups of *Oreochromis niloticus* collected from the three sectors of lake Burullus during 2002 (Moussa 2003).**

Length Group (cm)	Sector											
	Eastern				Middle				Western			
	Fish no.	Mtl	Mew	Mcw	Fish no.	Mtl	Mew	Mcw	Fish no.	Mtl	Mew	Mcw
8-10	36	9.21	10.4	10.1	44	9.23	11.2	11.1	78	9.11	11.5	13.4
10-12	85	11.1	17.3	17.3	156	11.3	19.3	20.6	96	11.3	27.3	27.3
12-14	66	12.9	28.3	26.6	78	13.4	32.4	33.7	103	13.2	47.9	44.5
14-16	74	15.1	40.3	42	65	14.9	52.5	46.7	129	15	81.4	68.8
16-18	47	16.8	53.7	57.8	51	16.9	74.1	68.8	84	16.9	112	101
18-20	19	18.6	70.5	76.9	18	19.3	95.5	102.0	8	19	148	148
20-22	12	20.8	103	107	24	21.3	129	137.0	15	21.2	195	212
22-24	8	23.0	155	143	12	23.2	182	177.0	5	22.9	245	275
24-26	2	25.2	198	186	-	-	-	-	-	-	-	-
26-28	2	27.1	228	229	-	-	-	-	-	-	-	-
Total	**351**	-	-	-	**448**	-	-	-	**518**	-	-	-
Mean		**18**	**90.5**	**89.5**		**16.2**	**74.5**	**74.6**		**16.1**	**109**	**111**

From these equations, it is evident that *O. niloticus* in the eastern sector decreases in weight by a rate less than the cube of length (n = 2.8944). In the middle sector the rate of increase in weight was nearly equal to the cube of length (n = 3.0042), whereas in the western sector this value exceeds 3 (n = 3.294).

For *Oreochromis aureus:*

Eastern sector (Fig. 9.3.a): $W = 0.0179\ L^{2.9036}$ ($R^2 = 0.9987$)
Middle sector (Fig. 9.3.b): $W = 0.0164\ L^{2.9471}$ ($R^2 = 0.9973$)
Western sector (Fig. 9.3.c): $W = 0.0153\ L^{2.9864}$ ($R^2 = 0.9979$)

Table 9.8 **Mean total length(Mtl), emperical weight (Mew) and calculated weight (Mcw) for different length groups of *Oreochromis aureus* collected from the three sectors of lake Borollus during 2002 (Moussa 2003).**

Length Group (cm)	Sector											
	Eatern				Middle				Western			
	Fish no.	Mtl	Mew	Mcw	Fish no.	Mtl	Mew	Mcw	Fish no.	Mtl	Mew	Mcw
8-10	75	9.13	11.9	11.3	54	9.22	10.5	11.4	33	8.97	13.7	10.5
10-12	136	11.4	21.4	22.2	112	11.3	19.5	21	68	11.3	21.7	20.6
12-14	118	13.5	34	36.8	99	13.4	36.8	34.1	92	13.8	37.2	37
14-16	63	15	46.2	50	86	14.9	50.1	47	43	15	52.5	46.5
16-18	34	17	66.7	72.2	37	16.9	67.6	68.7	31	17.1	74.1	68.8
18-20	13	19	96.6	100	27	19.3	93.3	101	4	19.3	104	98.2
20-22	6	21.5	127	145	2	21.3	138	134	6	21	138	125
22-24	4	23.1	163	180	2	23.2	174	173	2	22.8	175	159
24-26	-	-	-	-	-	-	-	-	-	-	-	-
26-28	-	-	-	-	-	-	-	-	-	-	-	-
Total	**449**	-	-	-	**419**	-	-	-	**279**	-	-	-
Mean		**16.2**	**70.8**	**77.3**		**16.2**	**73.7**	**73.9**		**16.2**	**77**	**70.7**

Table 9.9 **Mean total length(Mtl), emperical weight (Mew) and calculated weight (Mcw) for different length groups of *Sarotherdon galilaeus* collected from the three sectors of lake Burullus during 2002 (Moussa 2003).**

Length group	Sector											
	Eastern				Middle				Western			
	Fish no.	Mtl	Mew	Mcw	Fish no.	Mtl	Mew	Mcw	Fish no.	Mtl	Mew	Mcw
8-10	31	9.36	9.59	10.1	22	8.97	9.77	10.6	26	8.96	10	10.8
10-12	122	11.2	14.8	16.9	56	10.4	19.5	16.2	32	11	19.5	20
12-14	93	12.9	31.2	25.6	91	13.2	28.4	32.9	45	12.9	30.9	31.5
•;4-ie	75	15.3	42.7	41.2	64	15.1	49.8	48.3	25	15.1	55	51
16-18	32	16.9	57.5	55.2	42	17	66.3	68.3	27	16.1	77.6	61.1
18-20	10	18.9	77.9	75.2	7	19	96.7	94.8	5	19.1	102	102
20-22	4	21.1	97.7	103	4	21.2	138	130	6	21.2	120	138
22-24	-	23.1	126	135	2	23.1	162	168	3	23.1	170	179
24-26	-	-	-	-	-	-	-	-	-	-	-	-
26-28	-	-	-	-	-	-	-	-	-	-	-	-
Total	**367**	-	-	-	**288**	-	-	-	**169**	-	-	-
Mean		**16.1**	**57.2**	**57.8**		**16**	**71.4**	**71.2**		**15.9**	**73.2**	**74.2**

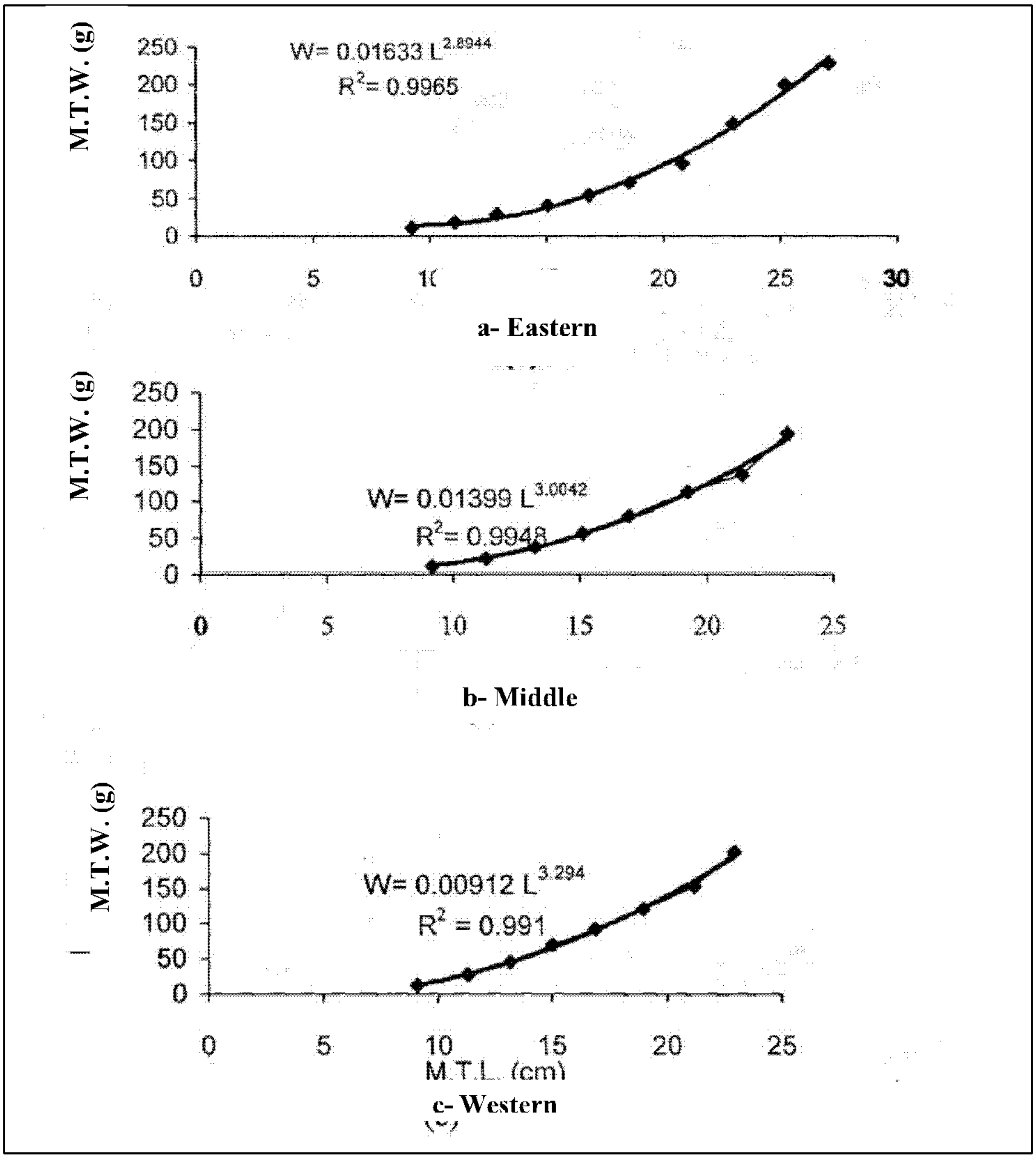


Fig. 9.2. **Length-weight relationship of *Oreochromis niloticus* in the three sectors of Lake Burullus during 2002 (Moussa 2003).**

From the above equations it is obvious that, the values of the exponent "n" or the regression factor (2.9036, 2.9471 and 2.9864, respectively) indicate that the rate of increase in weight was close to the cube (3) of length in the three sectors.

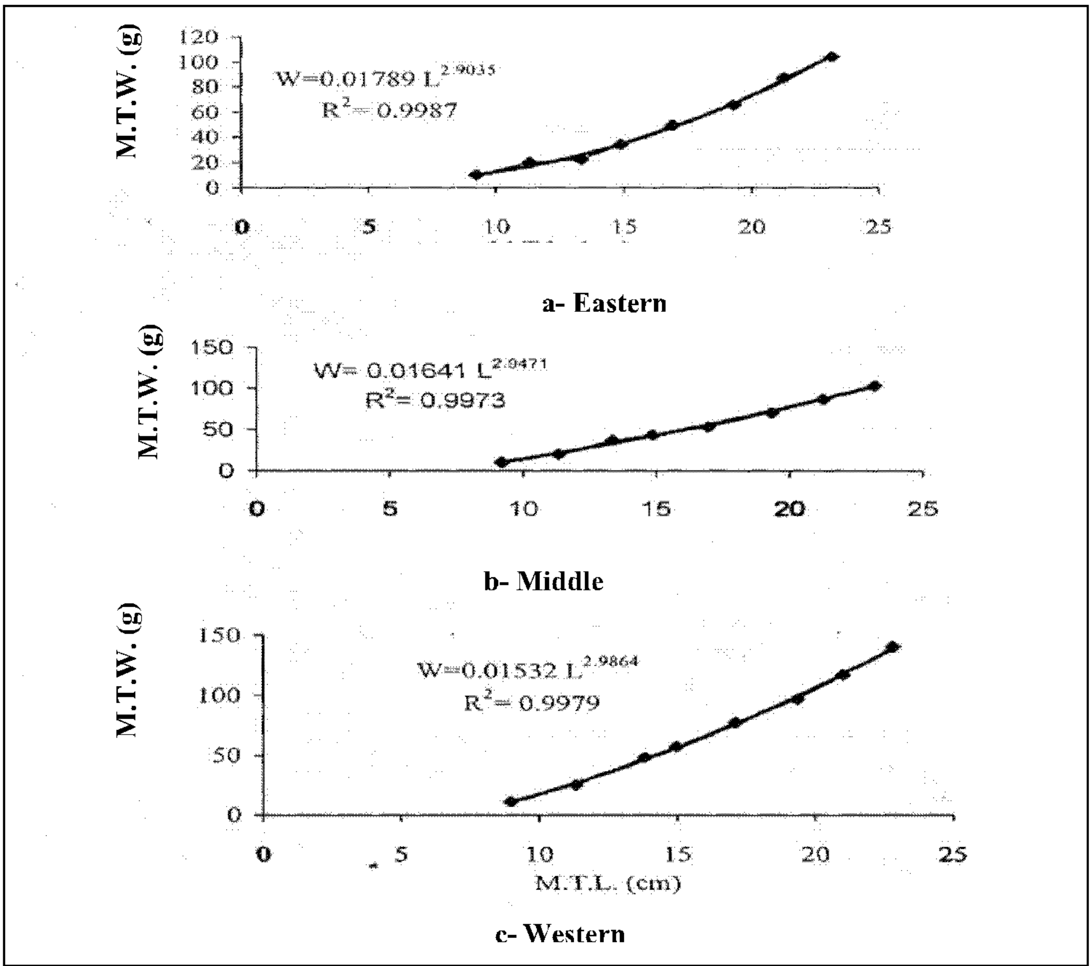


Fig. 9.3. **Length-weight relationship of *Oreochromis aureus* in the three sectors of Lake Burullus during 2002 (Moussa 2003).**

For *Sarotherodon galilaeus:*

Eastern sector (Fig. 9.4.a):	$W= 0.0244\ L^{2.8668}$	$(R^2 = 0.9876)$
Middle sector (Fig. 9.4.b):	$W= 0.0176\ L^{2.9179}$	$(R^2= 0.9900)$
Western sector (Fig. 9.4.c):	$W=0.0165\ L^{2.958}$	$(R^2 = 0.9861)$

From the above equations, the values of the exponent "n" (2.8668, 2.9179 and 2.958, respectively) indicate that the rate of increase in weight was close to the cube (3) of length, however it decreases in the eastern sector than the others. Since the value of exponent "n" is so close to 3.0 for all fish species, it could be stated that the weight of *Oreochromis niloticus, Oreochromis aureus* and *Sarotherodon galilaeus* increased approximately as the cube of the length.

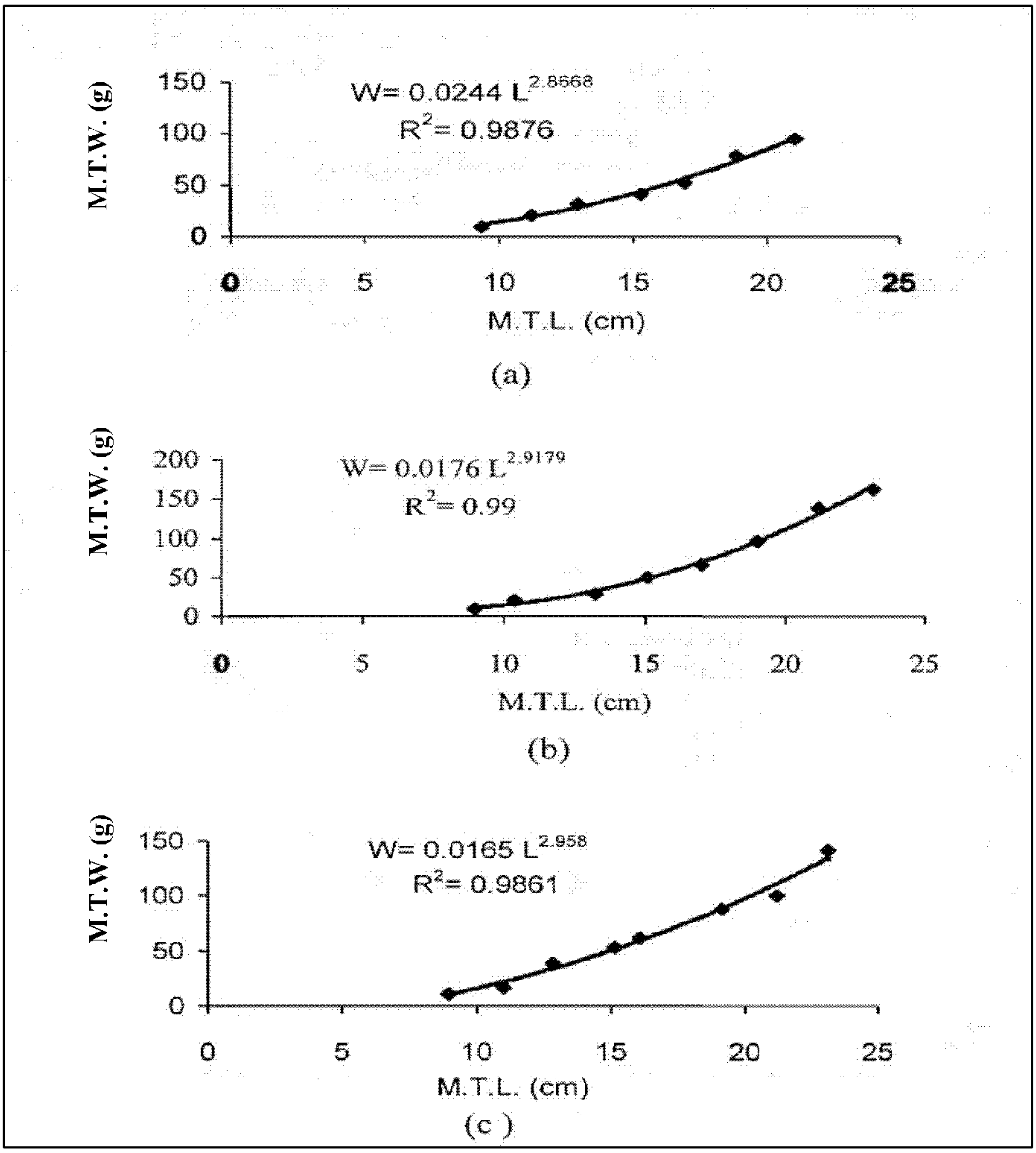


Fig. 9.4 **Length-weight relationship of *Sarotherodon galilaus* in the three sectors of Lake Burullus during 2002 (Moussa 2003).**

In comparing the weight of *O. niloticous* with other cichlid species (Tables 9.7, 9.8 and 9.9), it is obvious that *O. niloticous* was heavier than *O. aureus* and *S. galilaeus*. It was also noticed that the weight of *O. aureus* was little higher than that of *S. galilaeus*. For the same length group, we can see that fishes in the western sector are heavier than those in the eastern and middle sectors. This might be due to variations in the environmental conditions. In

addition, this finding may reflect the higher fertility and the suitable environmental factors of Lake Burullus.

9.3.1.6. Condition factor (K)

From Table (9.10) and Figure (9.5) it is clear that the highest value of (K) was observed in winter season (average 1.60), whereas the lowest one was recorded in summer (1.33). Regionally, the maximum value of (K) was recorded in fishes of the western sector with an annual average of 1.69. The minimum value (annual average 1.26) was observed in fishes of the eastern sector.

Table 9.10 **Seasonal average of condition factor (K) of some cichlid fish species collected from the three sectors of lake Burullus during 2002 (after Moussa 2003).** ***On*****:** ***Oreochromis niloticus*****,** ***Oa*****:** ***Oreochromis aureus*** **and** ***Sg*****:** ***Sarotherodon galilaeus*****. M: Mean.**

Season	Sector												Mean
	Eastern				Middle				Western				
	On	*Oa*	*Sg*	M	*On*	*Oa*	*Sg*	M	*On*	*Oa*	*Sg*	M	
winter	1.34	1.53	1.22	1.36	1.64	1.57	1.52	1.58	2.29	1.67	1.59	1.85	1.60
spring	1.21	1.41	1.14	1.25	1.49	1.35	1.42	1.42	2.04	1.52	1.47	1.68	1.45
summer	1.13	1.26	1.11	1.17	1.17	1.29	1.29	1.25	1.93	1.39	1.35	1.56	1.33
autumn	1.16	1.37	1.18	1.24	1.37	1.44	1.42	1.41	1.98	1.54	1.51	1.68	1.44
Mean	1.21	1.39	1.16	1.26	1.42	1.41	1.41	1.41	2.06	1.53	1.48	1.69	1.44

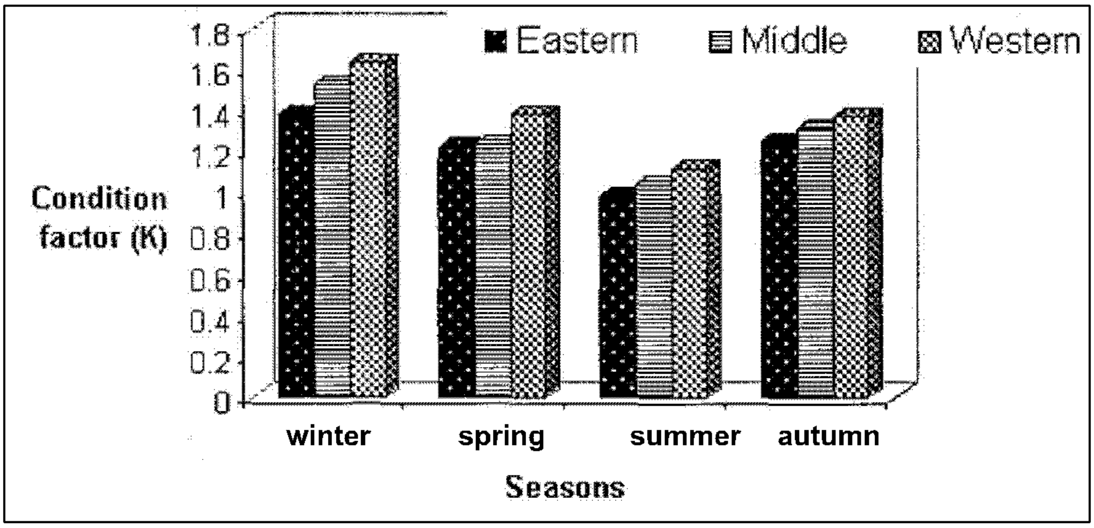


Fig. 9.5 **Seasonal variation of condition factor (K) of cichlid fish species collected from the three sectors of Lake Burullus during 2002 (after Moussa 2003)**

Regarding, the differences among fishes in different sectors, Table (9.11) and Figure (9.6) show that there is a difference in (K) value between the western sector (recorded highest mean of 2.06 ± 0.05) and both the eastern (recorded lowest mean 1.21 ±0.05) and the middle sector (average value 1.42 ± 0.05) for *O. niloticus*. No differences were present among the three sectors for *O. aureus*. For *S. galileus*, there is a significant difference between the western sector (mean 1.53 ± 0.03) and both the eastern and middle sectors. There is also a difference between the eastern (mean 1.16 ± 0.02) and middle (mean 1.41 ± 0.05) sectors.

Table 9.11. **Annual mean ± standard error of condition factor (K) and hepato-somatic index (HSI) of some cichlid species collected from the three sectors of Lake Burullus during 2002 (Moussa 2003). Capital letters represent difference among the different sectors; small letters represent difference within the same sector. Means with the same exponent are not different.**

Fish species	Condition factor (K)			Hepato-somatic index (HIS)		
	Eastern	Middle	Western	Eastern	Middle	Western
Oreochromis niloticus	1.21^{Ba} ±0.05	1.42^{Ba} ±0.05	2.06^{Aa} ±0.05	1.29^{Aa} ±0.12	1.32^{Aa} ±0.13	1.40^{Aa} ±0.23
Oreochromis aureus	1.39^{Aa} ±0.06	1.42^{Ba} ±0.05	2.06^{Aa} ±0.05	1.29^{Aa} ±0.06	1.32^{Aa} ±0.08	1.40^{Aa} ±0.09
Sarotherodon galilaeus	1.16^{Cb} ±0.02	1.41^{Ba} ±0.05	1.53^{Ab} ±0.03	1.04^{Ab} ±0.09	1.19^{Ab} ±0.10	1.30^{Ab} ±0.1

Concerning the differences among cichlid fishes in the same sector, it is shown from Table (9.11) that there is a significant difference between *O. niloticus* and *O. aureus* on one side and *S. galilaeus* on the other side in the eastern sector. In the middle sector, no differences were exhibited among fishes. On the other hand, the western sector showed significant differences between *O. niloticus* on one side and *O. aureus* and *S. galilaeus* on the other one.

9.3.1.7. Hepato-somatic index (HSI)

From Table (9.12) and Figure (9.7) it is shown that the highest value of K was obtained in winter season (average 1.52), whereas the lowest one was recorded in summer (average 1.03). Regionally, the highest value of HSI was recorded in fishes of the western sector with an annual average value of 1.37, whereas the lowest value (annual average 1.21) was observed in fishes of the eastern sector.

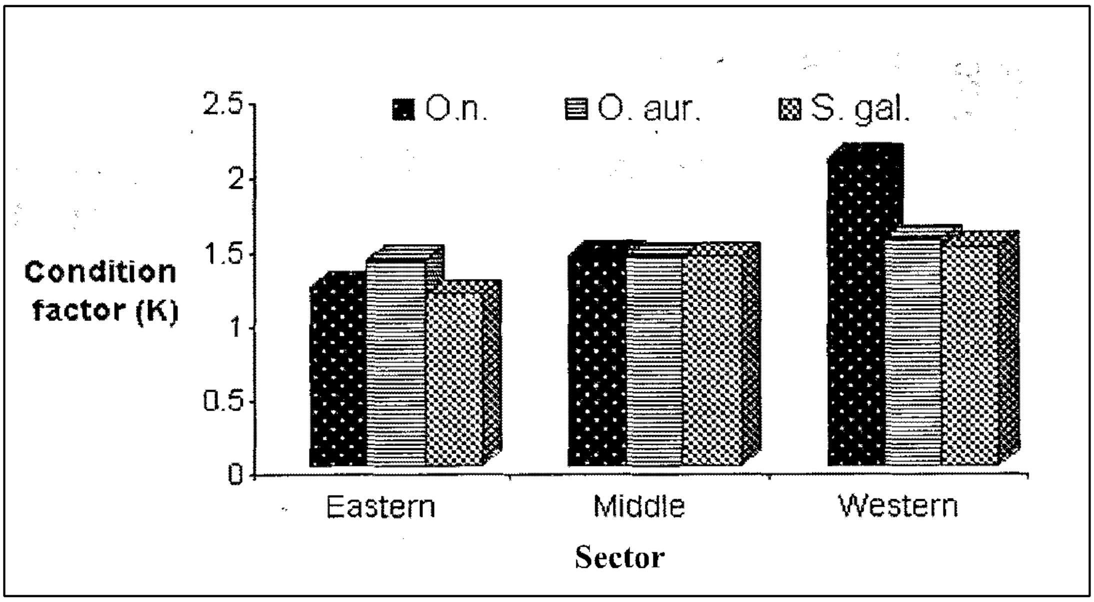


Fig. 9.6 **Comparison of condition factor (K) of cichlid fish species collected from the three sectors of Lake Burullus during 2002 (Moussa 2003).**

Table 9.12. **Seasonal average of hepato-somatic index (HSI) of some cichlid fish species collected from the three sectors of lake Burullus during 2002 (after Moussa 2003).** ***On*: *Oreochromis niloticus*, *Oa*: *Oreochromis aureus* and *Sg*: *Sarotherodon galilaeus*. M: Mean**

Season	Sector												Mean
	Eastern				Middle				Western				
	On	*Oa*	Sg	M	*On*	*Oa*	*Sg*	M	*On*	*Oa*	*Sg*	M	
Winter	1.45	1.42	1.26	1.38	1.62	1.51	1.45	1.53	1.76	1.64	1.49	1.63	1.52
spring	1.36	1.31	0.98	1.22	1.36	1.22	1.12	1.23	1.41	1.43	1.29	1.38	1.28
summer	0.96	1.14	0.83	0.98	0.97	1.17	0.97	1.04	1.13	1.18	1.03	1.11	1.03
Autumn	1.37	1.27	1.09	1.24	1.31	1.41	1.23	1.32	1.29	1.40	1.40	1.36	1.26
Mean	**1.29**	**1.29**	**1.04**	**1.2**	**1.32**	**1.33**	**1.19**	**1.28**	**1.40**	**1.41**	**1.30**	**1.37**	**1.27**

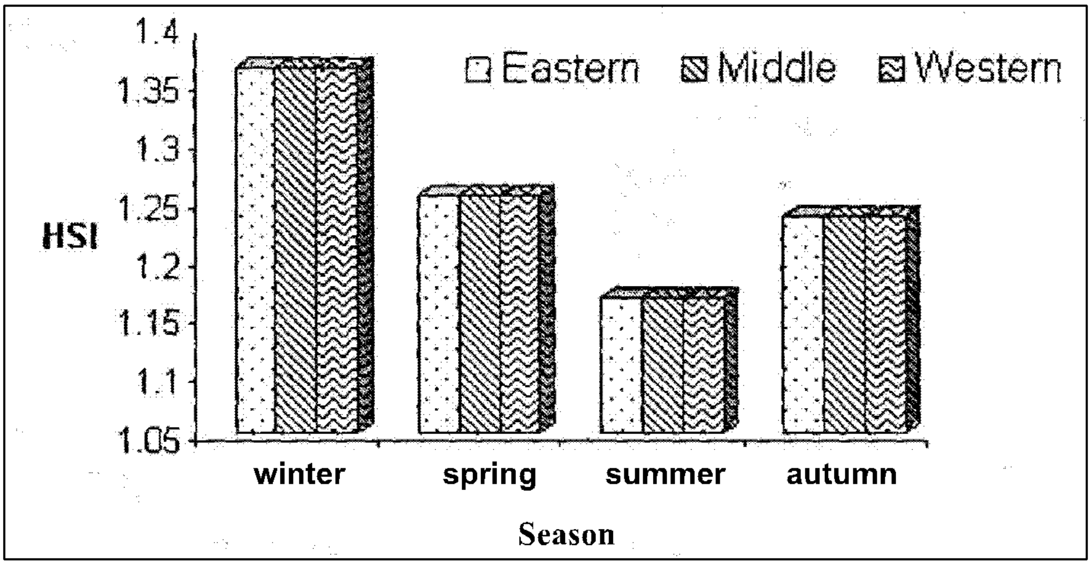


Fig. 9.7. **Seasonal variation of hepato-somatic index (HIS) of cichlid fish species collected from the three sectors of Lake Burullus during 2002 (after Moussa 2003).**

Regarding, the differences among fishes in different sectors, Table (9.11) and Figure (9.8) show that there is no difference in HSI values among the three sectors for *O. niolticus* (annual means of 1.39 ± 0.12, 1.32 ± 0.13 and 1.40 ± 0.23), *O. aureus* (annual means of 1.29 ± 0.06, 1.33 ± 0.08 and 1.40 ± 0.09) and *S. galilaeus* (annual means of 1.04 ± 0.09, 1.19 ± 0.10 and 1.30 ± 0.10) in the eastern, middle and western sector, respectively.

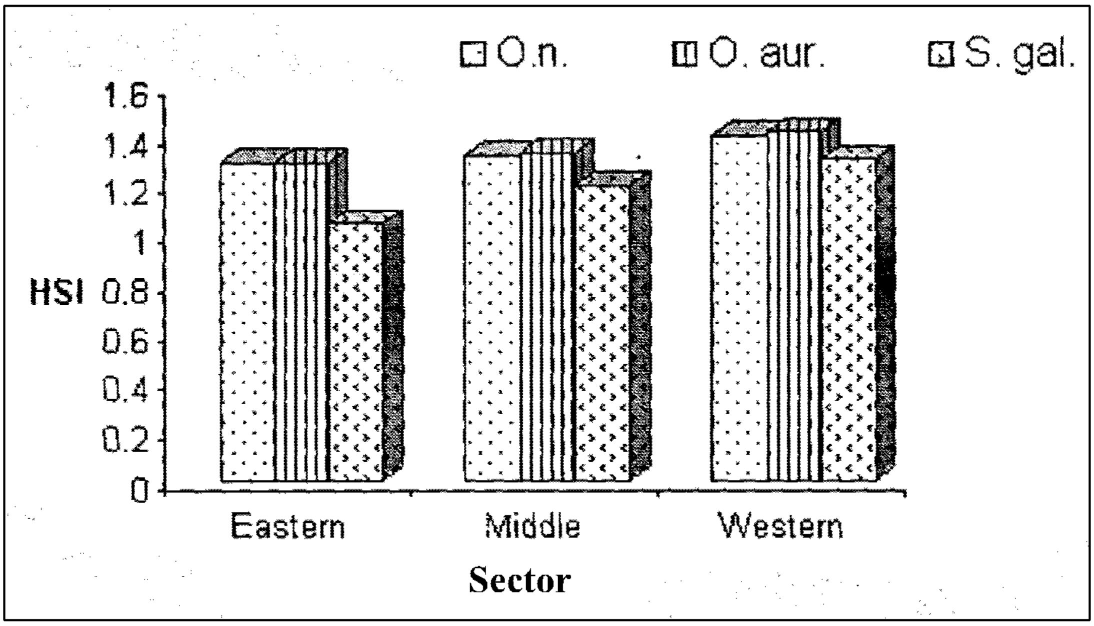


Fig. 9.8 **Comparison of hepato-somatic index (HIS) of cichlid fish species collected from the three regions of Lake Burullus during 2002 (after Moussa 2003)**

Concerning, the differences among cichlid fishes in the same sector, it is shown that, there is a significant difference between *O. niolticus* and *O. aureus* on one side, and *S. galilaeus* on the other side in the three sectors (Table 9.11). In general, it is clear that the value of K follows the same trend of HSI. *O. niloticus* seems more successful in Lake Burullus environment than the other two species, which have also better conditions.

9.3.2 Biology of Muglidae

Five species of mullets are present in Lake Burullus as follows: *Mugil cephalus* Linnaeus 1758, *Liza ramada* (Risso, 1826), *Liza aurata* (Risso. 1810), *Liza saliens* (Risso, 1810) and *Chelon labrosus* (Cuvier, 1829).

9.3.2.1. Seasonal fluctuation of the mullet catch

Liza ramada is the dominant species of mullet catch throughout the year. When the fish is fully ripe, it swarms and migrates from the lake to the sea. Its accessibility in the nets operating in the lake greatly increases during November and December when the fish is sexually ripe. The catch in autumn equals three times its production in any other season .

Mugil cephalus production ranks next to that of *L. ramada.* Its maximum yield is attained during summer, representing maturation period. Large-sized mature fish appear during July to September, where they swarm in the lake migrating to the sea to spawn.

The fishery of *Liza saliens* whose production comes next to that of *M. cephalus* extends from late spring to the beginning of autumn. The maximum fishing of this species was recorded in September, during which the fish leaves the area of the lake-sea connection, where it is localized and migrates to the sea.

Liza aurata and *Chelon labrosus* have disappeared completely from the mullet catch. They were only localized in the area of the lake-sea connection. Their absence from the water of the lake is explained by their disability to adjust to low salinity.

9.3.2.2. Monthly length frequency distribution of mullets

9.3.2.2.1. *Liza ramada*

The population of small sized individuals shows a clear modal distribution in January, February and March. These smaller size groups are well represented in such months, and represent immature fishes, which remain in the lake after the spawning migration of mature fish to the sea in the previous autumn. In March, large fishes (i.e. 210 & 240 mm TL), may represent the adult fish after performing their spawning in the sea.

The prominent peak which is obvious until June, declines down to be replaced by other modal peaks in July and August at 190, 200 and 220 mm TL.

This is due to rise in water temperature and the movement of fish from the vegetative areas to the open water (Hashem *et al.* 1973).

In September, all the length groups are well represented in the samples due to extensive fishing, so that there is no well identified modal distribution of length groups. Mature fishes start to swarm in the open water, coinciding with the ripening of their gonads. In November and December the older length groups not only lose their modal identity but also decrease in number, since they migrate to the sea. In December, a well-developed mode of younger individuals (150-170 mm) appears repeating the same behavior as in January .

It is possible to follow the monthly growth increment of length from the shift in the modal distribution of the length frequency. Starting from the mode of January at 160 mm, it shows a slight increase until April (170 mm). In May, the significant increase in the mode value is prominent, reaching 190 mm. In June and July, further pronounced increases in the mode value also take place (200 and 210 mm respectively). In the mean time, growth of the juvenile fish could be detected from other modes at 165, 180 and 190 mm in May, June and July, respectively.

9.3.2.2.2. *Mugil cephalus*

Prominent modes of small fish are represented in January, February, March and April. They represent young immature individuals in which the monthly increment of growth in length is slight. In May the small immature fish are still represented in the samples. The summer catch exhibits an increase in the percentage of large fishes. In June, large mature fishes appear mixed with smaller fishes and they form a distinct, but low mode at 300 and 320 mm. These large mature fishes persist in July, August and September; while the smaller individuals decrease considerably, because fishing is concentrated at that period on the larger mature fish swarming in the lake. They represent the fully ripe individuals, leaving the lake to spawn in the sea. From October till December, the younger individuals appear in the catch again.

9.3.2.2.3. *Liza saliens*

It is difficult to assess the monthly length distribution pattern for *L. saliens*, since the fish is confined to the area of the lake-sea connection, and its stay is limited (from May to September). From the observations recorded by Hashem *et al.* (1973), it was found that the unimodal distribution is represented in the whole catch. It is characterized by two distinct size groups, the first is nearly at 150 mm, and the second at 190 mm. These two values may characterise two distinct broods for the fish, which breeds twice, one in spring and the other in autumn.

9.3.2.3. Factors affecting the distribution of mullet fry

The hydrographic factors which characterize the lake allover the year, have a great effect on the population of any species. The strength of any year class depends largely on the favorable conditions during the different stages of life. In case of mullet, the success of early developmental stages is determined in the sea at the breeding grounds. The survival of the fry and juveniles, which invade the lake, depends on many environmental factors such as water movement, water temperature, chlorsity and amount of food, among others.

9.3.2.3.1. Water movement

It has been observed, while collecting the fry at the lake-sea connection, that the amount of fry depends upon the direction of the water current. A large number of fry were collected when the water was streaming to the sea. The fry seems to prefer swimming against the current; beside, the fresh water flowing out attracts the fry to the interior of the lake (El-Maghraby *et al.* 1974 a & b).

The water in the lake is almost calm near the shores and in the vegetative pans, but it may be strongly agitated in the open parts even when wind of modern velocity blows. Due to the shallowness of the lake, the eastern wind drives the water from Baltim region to the north west leaving the whole area dry, this in turn forces all the mullet fry present to seek other places. The eastern area of the lake is not affected by such wind, on the contrary all the water mass rushes to it and raises the water level, and the mullet fry can be seen swimming among the weeds and reeds (*Phragmites australis*) growing near the shores. The vegetative areas decrease the effect of wind and create a suitable favorable shelter for the fry. Western winds never dry the western part of the lake because it is rather deep; however, large amounts of water are driven to the eastern sector of the Lake.

9.3.2.3.2. Water temperature

The temperature of water varies between 12.5°C and I5.5°C in winter and from 26.0°C to 29.0°C in summer. Owing to the shallowness of the lake, there is no thermal stratification except during very short spells in spring and autumn, when extremely calm weather takes place. The comparatively higher temperature in the lagoon and outlets of channels attracts the fry to survive. They seem to prefer warm shallow water, which are always in thermal equilibrium with the atmosphere. In addition, the higher water temperature of these areas stimulates the development of diatoms and other microorganisms needed as the basic supply for the fry and young mullet (Zambriborch 1949).

9.3.2.3.3. Chlorosity

The chlorosity of the Lake is greatly affected by the amount of seawater on one hand, and drain and fresh water on the other hand. The chlorosity of the different areas of the lake controls the distribution of the fry and even the adults. The fry of euryhaline fishes like *L. ramada* and *M. cephalus* can invade the

whole lake and are found in all areas, while the fry of *L. saliens* prefer areas with high chlorosity and does not leave the area of the lake-sea connection. *L. aurata* and *Chelon labrosus* were always found much closer to the sea, because of their stenohaline nature, but during the present survey no specimen has been obtained. El-Boughaz area, which is greatly affected by the seawater more than drain water, acts as a transition area between the seawater and brackish water of the lake. Huge amounts of fry rush into this area and they seem to stay for a while to acclimatize themselves before spreading in different sectors of the lake.

9.3.2.3.4. Amount of food

The mullet as a whole is a grazer, feeding on living organisms or organic material accumulated on the lake bottom. When observing the fry of *L. ramada* and *M. cephalus*, they were reported to descend to the bottom and gulp a portion of the sand or mud and then reject it after retaining the organic content in their special filtering apparatus present in the oesophagus. The amounts of organic materials (detritus) in Delta lakes are great, and the variety of plant and animal microorganisms living on their bottom provide a rich source of suitable food for the mullet.

9.3.2.3.5. Other factors

Many authors have discussed the effect of some other factors on the distribution of the mullet fry. De Angelies (1960) mentioned that dissolved oxygen, alkalinity, and the presence of dissolved nitrates were important factors affecting the biological productivity of lagoon waters and hence the abundance of mullet fry. Creutzberg (1961) during his experimental study on the migrating elvers of *Anguilla anguilla* and mullet, found that they are attracted to some organic compounds present in inland waters. It is suggested that the small inorganic and plant detritus sediment particles are richer than the coarser material that the mullet rejects.

9.3.3. Heavy Metals in Fish Organs

Moussa (2003) studied the spatial and temporal variations in concentration of heavy metals (Zn, Cu, Fe, Cd and Pb) in three cichlid species (*Oreochromis niloticus*, *Oreochromis aureus* and *Sarotherodon galilaeus*) in Lake Burullus. Tables 9.13, 9.14 and 9.15 show the seasonal average concentrations of the estimated heavy metals in the different tissues of the three cichlid species collected from the three sectors of Lake Burullus. It is clear that, the concentrations of metals as a whole increase in fish organs in autumn and summer (average 45.32 and 42.45 $\mu g\ g^{-1}$ dry wt., respectively) and decrease in winter and spring seasons (average 11.12 and 19.22 $\mu g\ g^{-1}$. dry wt., respectively).

Table 9.13. **Seasonal average of heavy metals concentration ((μg g^{-1} dry wt.) in tissues of some cichlid fish species collected from the eastern sector of lake Burullus during 2002 (Moussa 2003).**

Species	Metal	Winter			Spring			Summer			Autumn		
		Muscle	Gill	Liver	Muscle	Gill	Liver	Muscle	Gill	Liver	Muscle	Gill	Liver
Oreochromis niloticus	Zn	3.53	9.62	10.47	4.32	18.00	13.60	15.20	58.90	48.40	16.40	23.90	68.20
	Cu	1.13	1.33	16.26	4.25	5.96	21.80	5.12	8.73	29.10	5.38	7.51	28.30
	Fe	11.8	50.10	74.69	13.90	71.90	109.0	20.60	146.0	287.0	33.20	172.0	301.0
	Cd	0.01	0.04	0.05	0.03	0.07	0.10	0.05	0.06	1.02	0.09	1.11	1.19
	Pb	1.58	5.17	4.78	1.45	3.62	7.65	1.87	6.94	10.60	1.92	5.69	9.94
	Mean	**3.62**	**13.25**	**21.25**	**4.80**	**19.91**	**30.44**	**8.58**	**44.19**	**75.19**	**11.38**	**42.07**	**81.81**
Oreochromis aureus	Zn	2.76	4.36	11.3	13.30	11.10	44.00	19.80	39.20	71.20	17.30	71.70	42.60
	Cu	2.83	3.26	13.1	4.25	6.32	24.10	7.91	21.10	34.50	5.31	6.67	29.30
	Fe	8.21	23.00	35.3	21.00	36.60	101.0	36.00	162.0	233.0	62.60	296.0	331.0
	Cd	0.11	0.36	0.42	0.14	0.46	1.06	0.09	0.54	1.25	0.19	0.63	1.12
	Pb	2.44	6.45	6.81	2.66	8.73	9.61	2.41	7.49	10.70	2.01	6.54	11.30
	Mean	**3.27**	**10.60**	**13.4**	**8.27**	**16.60**	**36.00**	**13.20**	**45.10**	**70.20**	**17.50**	**57.70**	**83.10**
Sarotherodon galilaeus	Zn	1.45	8.37	7.89	3.35	18.80	32.00	21.20	36.30	40.30	11.00	30.10	37.10
	Cu	1.56	3.92	8.33	6.11	7.22	18.20	4.56	6.11	20.10	7.03	8.28	19.30
	Fe	5.77	42.20	86.10	10.40	68.20	103.0	23.20	184.0	274.0	21.20	141.0	278.0
	Cd	0.01	0.03	0.06	0.02	0.07	0.07	0.04	0.08	0.09	0.10	0.15	0.23
	Pb	1.07	2.41	4.32	1.36	6.49	9.17	1.96	6.11	9.32	1.83	5.84	10.60
	Mean	**1.97**	**11.40**	**21.3**	**4.25**	**20.10**	**32.50**	**10.20**	**46.50**	**68.80**	**8.23**	**37.10**	**69.10**

Concerning the annual means of heavy metals in fish organs, Moussa (2003) obtained the following data:

9.3.3.1. Muscle tissues

In muscle tissues of the three cichlid fish species collected from the eastern sector, it is clear that there is no significant difference among the three fishes for Zn, Cu and Fe (Table 9.16 and Fig. 9.9). The highest values of Zn, Cu and Fe (13.28±3.75, 5.08±1.07 and 31.96±11.68 μg g^{-1}) were recorded in muscle tissues of *Oreochromis aureus*. The lowest values were observed in muscle tissues of *Sarotherodon galilaeus* with means of 9.24±4.48, 4.82±1.20 and 15.13±4.19 μg g^{-1}, respectively. On the other hand, for Cd and Pb there is significant difference between *Oreochromis aureus* (mean= 0.13±0.02 and 2.38±0.14 μg g^{-1}) from one side and *Oreochromis niloticus* (mean= 0.045±0.02 and 1.71 ±0.11 μg g^{-1}) and *Sarotherodon galilaeus* (mean= 0.042±0.02 and 1.56±0.21 μg g^{-1}) from the other side. No significant differences exist between *Oreochromis niloticus* and *Sarotherodon galilaeus*.

Table 9.14. **Seasonal average of heavy metals concentration (($\mu g\ g^{-1}$ dry wt.) in tissues of some cichlid fish species collected from the middle sector of lake Burullus during 2002 (after Moussa 2003).**

Species	Metal	Winter			Spring			Summer			Autumn		
		Muscle	Gills	Liver	Muscle	Gills	Liver	Muscle	Gills	Liver	Muscle	Gills	Liver
Oreochromis niloticus	Zn	3.82	19.65	31.22	16.02	22.56	26.35	11.14	31.56	59.68	18.68	37.32	35.18
	Cu	1.68	6.11	10.42	3.12	7.02	15.26	5.16	8.64	29.18	7.22	11.34	31.02
	Fe	19.05	68.24	93.12	42.94	255.1	412.0	55.16	224.9	302.2	41.89	134.4	200.9
	Cd	0.02	0.26	0.32	0.04	0.37	0.23	0.03	0.61	0.77	0.03	0.53	1.32
	Pb	1.12	1.75	2.86	1.03	2.01	2.91	2.09	4.61	5.47	1.52	4.97	8.04
	Mean	**5.138**	**19.2**	**27.59**	**12.63**	**57.42**	**91.35**	**14.72**	**54.05**	**79.45**	**13.87**	**37.72**	**55.29**
Oreochromis aureus	Zn	4.15	10.38	25.67	17.02	41.26	33.12	26.81	41.53	77.16	27.91	78.39	120.4
	Cu	5.08	6.25	14.99	6.11	10.35	23.21	7.15	11.02	25.14	8.42	16.25	33.52
	Fe	13.42	118.4	155.8	18.30	106.3	272.0	61.93	126.2	351.3	54.22	177.5	321.3
	Cd	0.03	0.43	0.35	0.04	0.62	1.00	0.05	0.83	0.93	0.07	0.72	1.07
	Pb	1.55	3.22	10.06	2.21	9.23	13.2	3.08	8.63	9.41	3.63	9.73	7.85
	Mean	**4.85**	**27.74**	**41.37**	**8.74**	**33.56**	**68.51**	**19.80**	**37.64**	**92.78**	**18.85**	**56.52**	96.82
Sarotherodon galilaeus	Zn	3.76	11.82	14.57	4.22	25.18	33.27	11.35	29.22	40.25	13.69	43.37	46.31
	Cu	2.09	4.60	9.55	3.13	12.14	12.09	4.02	10.22	17.25	4.11	14.58	27.16
	Fe	17.35	43.25	79.73	32.70	121.4	270.9	27.30	113.3	366.5	46.17	127.1	341.0
	Cd	0.02	0.20	0.36	0.03	0.23	0.39	0.03	0.47	0.44	0.03	0.40	0.41
	Pb	1.37	2.63	3.43	1.03	2.01	8.57	2.09	4.61	8.47	2.01	2.97	13.04
	Mean	**4.92**	**12.5**	**21.53**	**8.22**	**32.2**	**65.05**	**8.96**	**31.55**	**86.57**	**13.20**	**37.69**	**85.59**

In the middle sector, there is no significant difference among the three species for Zn. For Cu, a significant difference was present between *O. aureus* (mean= 6.69±0.71 $\mu g\ g^{-1}$) and *S. galilaeus* (mean= 3.34±0.47 $\mu g\ g^{-1}$), but no significant difference between *O. niloticus* (mean= 4.30±1.21 ($\mu g\ g^{-1}$) and the other two fishes. However, no significant difference recorded among the three fishes for Fe. For Cd, there is a significant difference between *0. aureus* (mean= 0.046±0.008 $\mu g\ g^{-1}$*)* from one side and *O. niloticus* (mean= 0.029±0.003 $\mu g\ g^{-1}$) and *S. galilaeus* (mean= 0.027±0.002 $\mu g\ g^{-1}$) from the other side. No significant difference exists between *O. niloticus* and *S.. galilaeus.* Concerning Pb, there is a significant difference between *O. aureus (mean*= 2.62±0.46 $\mu g\ g^{-1}$) and *O. niloticus* (mean= 1.44±0.24 $\mu g\ g^{-1}$) but there is no significant difference between *S. galilaeus* (mean= 1.63±0.26 $\mu g\ g^{-1}$) and the other two fish species.

Table 9.15. **Seasonal average of heavy metals concentration (($\mu g\ g^{-1}$ dry wt.) in tissues of some cichlid fish species collected from the western sector of lake Burullus during 2002 (after Moussa 2003).**

Fish sp.	Metal	Winter			Spring			Summer			Autumn		
		Muscle	Gills	Liver	Muscle	Gills	Liver	Muscle	Gills	Liver	Muscle	Gills	Liver
Oreochromis niloticus	*Zn*	5.21	19.32	26.11	15.04	36.28	42.10	25.03	67.29	66.47	22.86	51.27	84.48
	Cu	1.95	5.01	9.22	2.66	7.55	17.24	8.36	14.25	33.63	7.33	17.51	35.02
	Fe	14.13	22.17	106.1	44.02	93.11	621.6	56.15	87.21	542.1	42.05	401.8	693.2
	Cd	0.02	0.26	0.32	0.02	0.25	0.41	0.03	0.29	0.56	0.02	0.32	0.47
	Pb	0.95	1.44	2.35	0.98	1.92	3.66	1.46	2.25	6.21	1.54	2.13	7.02
	Mean	**4.45**	**9.64**	**28.82**	**12.54**	**27.82**	**137**	**18.21**	**34.26**	**17.9.8**	**14.76**	**94.61**	**164**
Oreochromis aureus	Zn	11.81	21.11	25.17	17.12	41.25	58.19	47.28	105.2	133.2	38.57	57.89	81.28
	Cu	4.37	6.35	17.23	4.91	7.17	35.2	6.42	17.35	29.11	9.11	17.01	32.18
	Fe	23.15	80.29	62.21	103.1	340.7	254.0	96.14	567.1	267.3	74.14	345.7	476.9
	Cd	0.02	0.19	0.41	0.03	0.27	0.55	0.05	0.39	0.54	0.04	0.44	0.43
	Pb	1.08	2.18	2.64	1.96	2.31	4.71	1.84	2.58	6.21	1.79	3.55	7.81
	Mean	**8.09**	**22.02**	**21.53**	**25.43**	**78.34**	**70.53**	**30.35**	**138.5**	**87.26**	**24.73**	**84.91**	**119.7**
Sarotherodon galilaeus	Zn	14.35	33.14	21.15	11.52	29.87	36.58	21.35	42.16	77.28	19.41	53.58	76.12
	Cu	1.44	9.25	10.77	5.16	10.44	17.25	3.11	16.35	31.12	6.35	12.58	29.14
	Fe	11.3	75.89	86.01	53.17	318.3	325.2	64.12	301.2	258.1	53.07	265.5	318.3
	Cd	0.01	0.11	0.29	0.02	0.21	0.25	0.02	0.29	0.31	0.02	0.31	0.30
	Pb	0.87	1.33	3.01	1.12	1.85	2.41	1.36	3.02	3.92	1.41	2.44	6.25
	Av.	**5.595**	**23.94**	**24.25**	**14.2**	**72.12**	**76.33**	**17.99**	**72.61**	**74.15**	**16.05**	**66.89**	**86.01**

Table 9.16 **Annual mean ± standard error of heavy metals concentrations ($\mu g\ g^{-1}$ dry wt.) in muscle tissues of some cichlid fish species collected from the three sectors of lake Burullus during 2002 (after Moussa 2003). Capital letters in the exponent represent the difference among fishes in different sectors; small letters refer to difference among fish of the same sector.** ***On: Oreochromis niloticus, Oa: Oreochromis aureus, Sg: Sarotherodon galilaeus.***

Metal	Sector								
	Eastern sector			Middle sector			Western sector		
	On	*Oa*	*Sg*	*On*	*Oa*	*Sg*	*On*	*Oa*	*Sg*
Zn	9.86^{Aa} ±3.44	13.28^{Aa} ±3.75	9.24^{Aa} ±4.48	12.42^{Aa} ±3.26	18.97^{Aa} ±5.51	8.26^{Aa} ±2.51	17.04^{Aa} ±4.49	28.70^{Aa} ±8.48	16.66^{Aa} ±2.26
Cu	3.97^{Aa} ±0.98	5.08^{Aa} ±1.07	4.82^{Aa} ±1.20	4.30^{Aba} ±1.21	6.69^{Aa} ±0.71	3.34^{Ba} ±0.47	5.08^{Aa} ±1.62	6.20^{Aa} ±1.06	4.02^{Aa} ± 1.09
Fe	19.89^{Aa} ±4.81	31.96^{Aa} ±11.68	15.13^{Ab} ±4.19	39.76^{Aa} ±7.53	36.96^{Aa} ±12.33	30.88^{Ab} ±6.01	39.09^{Aa} ±8.88	74.14^{Aa} ±18.08	45.42^{Aa} ±11.66
Cd	0.045^{Ba} ±0.02	0.13^{Aa} ±0.02	0.042^{Ba} ±0.15	0.029^{Ba} ± 0.003	0.046^{Ab} ±0.008	0.027^{Ba} ± 0.002	0.019^{Aa} ±0.002	0.033^{Ab} ± 0.006	0.021^{Aa} ±0.003
Pb	1.71^{Ba} ±0.11	2.38^{Aa} ±0.14	1.56^{Ba} ±0.21	1.44^{Ba} ±0.24	2.62^{Aa} ±0.46	1.63^{Aba} ±0.26	$1\ 23^{Aa}$ ±0.16	1.67^{Aa} ±0.20	1.19^{Aa} ±0.12

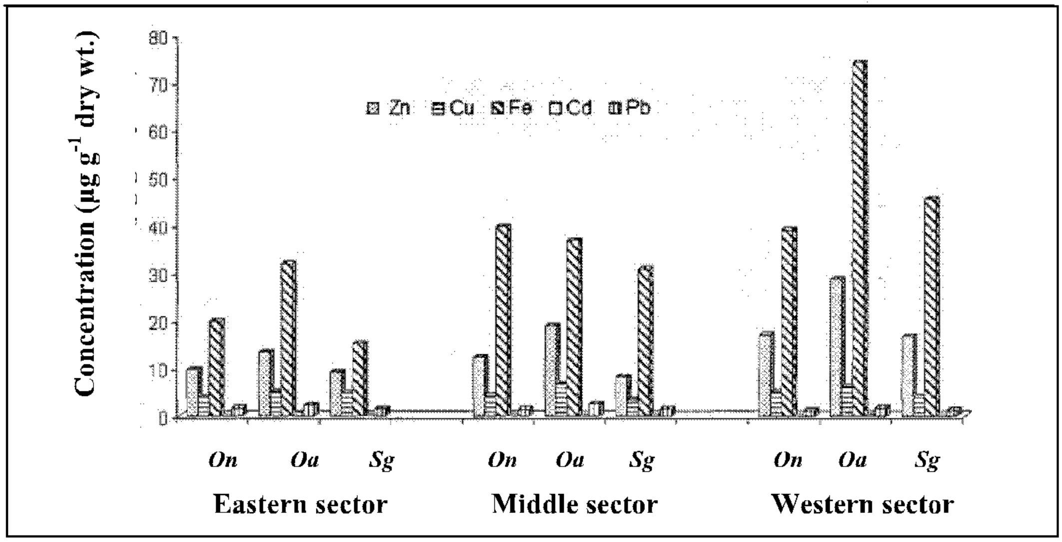


Fig. 9.9 **Annual mean of heavy metals concentration (µg g^{-1} dry wt.) in muscle tissues of some cichlid fish species collected from the three sectors of Lake Burullus during 2002 (after Moussa 2003)**

In the western sector, the accumulation of different heavy metals in the three fish species showed no significant difference. There is no significant difference between fishes collected from the three sectors for accumulation of Zn, Cu and Pb (Table 9.16). For Fe, there is no difference between fishes (*O. niloticus* and *O. aureus*) of the three sectors.

For the whole lake, metals in muscle tissues were accumulated in the order of Fe >Zn >Cu > Pb > Cd with an annual average of 37.03, 14.94, 4.83, 1.71 and 0.044 µg g^{-1} (Table 9.16). *O. aureus* accumulated metals more than the other two species. The annual average were 13.34, 11.40 and 10.39 µg g^{-1} for *O. aureus, S. galilaeus* and *O. niloticus,* respectively.

9.3.3.2. Gills tissues

The annual variations in heavy metals accumulation in gills tissues of different cichlid species collected from the three sectors of Lake Burullus are shown in Table 9.17 and Fig. 9.10.

In the eastern sector, the accumulation of different heavy metals in the three fish species showed no significant difference. The highest value of Zn, Cu, Fe, Cd and Pb were detected in gills of *O. aureus* with annual means of 31.58±15.36, 9.35±4.01, 129.49±63.80, 0.50±0.06 and 7.30±0.53 µg g^{-1}, respectively. The lowest values of Zn, Fe, Cd and Pb were recorded in *S. galilaeus*, with annual means of 23.39±6.18, 108.91±32.68, 0.08±0.025 and 5.21±0.94 µg g^{-1}, respectively. However, the minimum value of Cu was recorded in gills of *O. niloticus* (annual mean= 5.88±1.62 µg g^{-1}).

Table 9.17. **Annual mean ± standard error of heavy metals concentrations (μg g^{-1} dry wt.) in gills tissues of some cichlid fish species collected from the three sectors of lake Burullus during 2002 (Moussa 2003). Capital letters in the exponent represent the difference among fishes in different sectors; small letters refer to difference among fish of the same sector. *On: Oreochromis niloticus, Oa: Oreochromis aureus, Sg: Sarotherodon galilaeus.***

Metal	Sector								
	Eastern			Middle			Western		
	On	*Oa*	*Sg*	*On*	*Oa*	*Sg*	*On*	*Oa*	*Sg*
Zn	27.61^{Aa} ±10.83	31.58^{Aa} ±15.36	23.39^{Aa} ±6.18	27.77^{Aa} ±4.07	42.89^{Aa} ±13.91	*27.4*^{Aa} ±6.49	43.54^{Aa} ±10.26	56.36^{Aa} ±17.92	39.69^{Aa} ±5.31
Cu	5.88^{Aa} ±1.62	9.35^{Aa} ±4.01	6.38^{Ab} ±1.20	8.28^{Aa} ±1.15	10.97^{Aa} ±2.05	10.39^{Aab} ±2.12	11.08^{Aa} ±2.90	11.97^{Aa} ±3.01	12.16^{Aa} ±1.56
Fe	110.12^{Aa} ±29.19	129.49^{Aa} ±63.80	108.91^{Ab} ±32.68	170.67^{Aa} ±42.69	132.11^{Aa} ±15.68	101.26^{Ab} ±19.55	151.08^{Aa} ±85.12	333.99^{Aa} ±99.54	240.23^{Aa} ±55.87
Cd	0.32^{Aa} ±0.26	0.50^{Aab} ±0.06	0.080^{Ab} ±0.025	0.443^{Aba} ±0.079	0.65^{Aa} ±0.085	0.325^{Ba} ±0.065	0.280^{Aa} ±0.016	0.323^{Ab} ±0.057	0.230^{Aab} ±0.045
Pb	5.36^{Aa} ±0.69	7.30^{Aa} ±0.53	5.21^{Aa} ±0.94	3.34^{Bab} ±0.84	7.70^{Aa} ±1.51	3.06^{Ab} ±0.56	1.94^{Ab} ±0.18	2.66^{Ab} ±0.31	2.16^{Ab} ±0.37

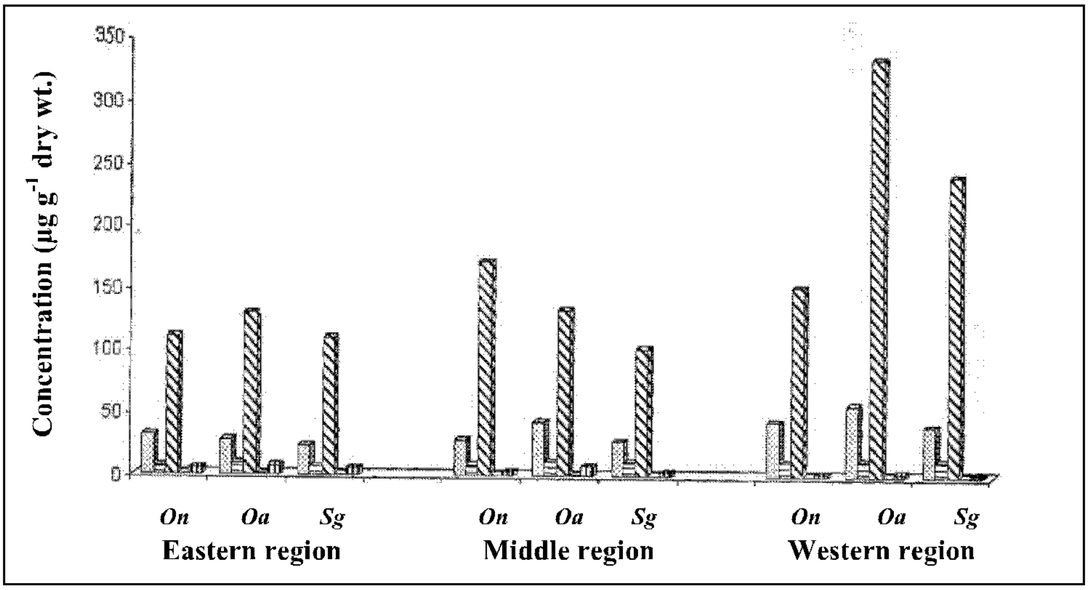


Fig. 9.10. **Annual mean of heavy metals concentration (μg g^{-1} dry wt.) in gills tissues of some cichlid fish spcies collected from the three sectors of Lake Burullus during 2002 (after Moussa 2003)**

In the middle sector, no significant differences exist between the three species for Zn, Cu, Fe and Cd. However, Pb accumulation showed significant

difference between *O. aureus* (7.70±1.51 μg g^{-1}) and *S. galilaeus* (3.06±0.56 μg g^{-1}) on one side, and *O. niloticus* (3.34±0.84 μg g^{-1}) on the other one.

Metals accumulated in gills tissues of fish collected from the western sector showed no significant difference. The minimum values of Zn, Cd and Pb were detected in gills tissues of *S. galilaeus* with annual means of 39.69±5.31, 0.230±0.045 and 2.16±0.37 μg g^{-1}, respectively. However, the lowest values of Cu and Fe were recorded in *O. niloticus* with annual means of 11.08±2.90 and 151.08±85.12 μg g^{-1}, respectively. The maximum values of Zn, Cu, Fe, Cd and Pb were detected in gills tissues of *0. aureus* with annual means of 56.36± 17.92, 11.97±3.01, 333.99±99.54, 0.323±0.057 and 2.66±0.31 μg g^{-1}, respectively. There is no significant difference between fishes collected from the three sectors for accumulation of Zn, Cu (except *S. galilaeus* which exhibits significant difference between the west and east of the lake for Cu). For Fe, there is a significant difference between the western sector and both of other sectors. For Cd, *O. niloticus* showed no significant difference among the three sectors (Table 9.17). However, there is a significant difference between the middle sector on one side, and both of other sectors on the other side for *O. aureus* and *S. galilaeus.* For Pb, there is a significant difference between the eastern and western sector and no difference between the middle and both of the eastern and western sectors for *O. niloticus*. A significant difference also present between the eastern and middle sectors on one side, and the western sector on the other side for *O. aureus.* Regarding *S. galilaeus*, a significant difference was detected between the eastern sector and both of the middle and western sectors.

For the whole lake, metals in gills tissues were accumulated in the order of Fe >Zn >Cu > Pb > Cd with annual averages of 164.21, 35.85, 9.61, 14.30 and 0.35 μg g^{-1} (Table 9.17). *O. aureus* accumulated more metals than the other two species. The annual averages were 5.89, 3.55 and 3.48 μg/g for *O. aureus, O. niloticus* and *S. galilaeus,* respectively.

9.3.3.3. Liver tissues

The annual variations in heavy metals accumulation in liver tissues of different cichlid species collected from the three sectors of lake Burullus are shown in Table 9.18 and Figure 9.11.

In the eastern sector, the accumulation of different heavy metals in the three fish species showed no significant difference, except Cd which showed difference between *O. aureus* and *S. galilaeus.* The highest value of Zn, Cu, Fe, Cd and Pb were detected in liver tissue of *O. aureus* with annual means of 42.29±12.25, 25.26±4.57, 193.01±58.89, 0.96±0.19 and 9.60±0.99 μg g^{-1}, respectively. The lowest values of Zn, Cu and Cd were recorded in *S. galilaeus*, with annual means of 29.31±7.34, 1.6.49±2.75 and 0.113±0.039 μg g^{-1}, respectively. However, the minimum value of Fe and Pb were detected in liver

tissue of *O. niloticus* (annual mean = 175.23±66.27 and 8.24±1.32 μg g^{-1}, respectively).

Table 9.18 **Annual mean ± standard error of heavy metals concentrations (μg g^{-1} dry wt.) in liver tissues of some cichlid fish species collected from the three sectors of lake Burullus during 2002 (Moussa 2003). Capital letters in the exponent represent the difference among fishes in different sectors; small letters refer to difference among fish of the same sector. *On: Oreochromis niloticus, Oa: Oreochromis aureus, Sg: Sarotherodon galilaeus.***

Metal	Sector								
	Eastern			Middle			Western		
	On	*Oa*	*Sg*	*On*	*Oa*	*Sg*	*On*	*Oa*	*Sg*
Zn	35.17 ^{Aa} ±13.97	42.29 ^{Aa} ± 12.25	29.31 ^{Aa} ±7.34	38.11 ^{Aa} ±7.41	64.09 ^{Aa} ±21.93	33.6 ^{Aa} ±6.88	54.79 ^{Aa} ±12.91	74.45 ^{Aa} ± 22.71	52.78 ^{Aa} ±14.17
Cu	23.84 ^{Aa} ±3.0	25.26 ^{Aa} ±4.57	16.49 ^{Aa} ±2.75	21.47 ^{Aa} ±5.09	24.22 ^{Aa} ±3.80	16.51 ^{Aa} ±3.89	23.78 ^{Aa} ±6.31	28.43 ^{Aa} ±3.93	22.07 ^{Aa} ±4.85
Fe	175.23 ^{Ab} ± 66.27	193.01 ^{Aa} ± 58.89	185.49 ^{Aa} 52.56	252.05 ^{Aa} ±68.29	275.08 ^{Aab} ±42.99	264.54 64.83 ^{Aa}	264.95 ^{Aa} ± 84.61	490.76 ^{Aa} ±131.88	246.9 ^{Aa} ± 55.70
Cd	0.59 ^{ABa} ±0.30	0.96 ^{Aa} ±0.19	0.113 ^{Bc} ±0.039	0.66 ^{Aa} ± 0.250	0.838 ^{Aa} ±0.165	0.400 ^{Aa} ±0.017	0.440 ^{Aa} ± 0.050	0.483 ^{Aa} ± 0.036	0.288 ^{Bb} ±0.013
Pb	8.24 ^{Aa} ±1.32	9.60 ^{Aa} ±0.99	8.35 ^{Aa} ±1.38	4.82 ^{Ba} ±1.23	10.13 ^{Aa} ±1.12	8.38 ^{ABb} ±1.96	4.81 ^{Aa} ±1.09	5.34 ^{Ab} ±1.10	3.90 ^{Aa} ±0.84

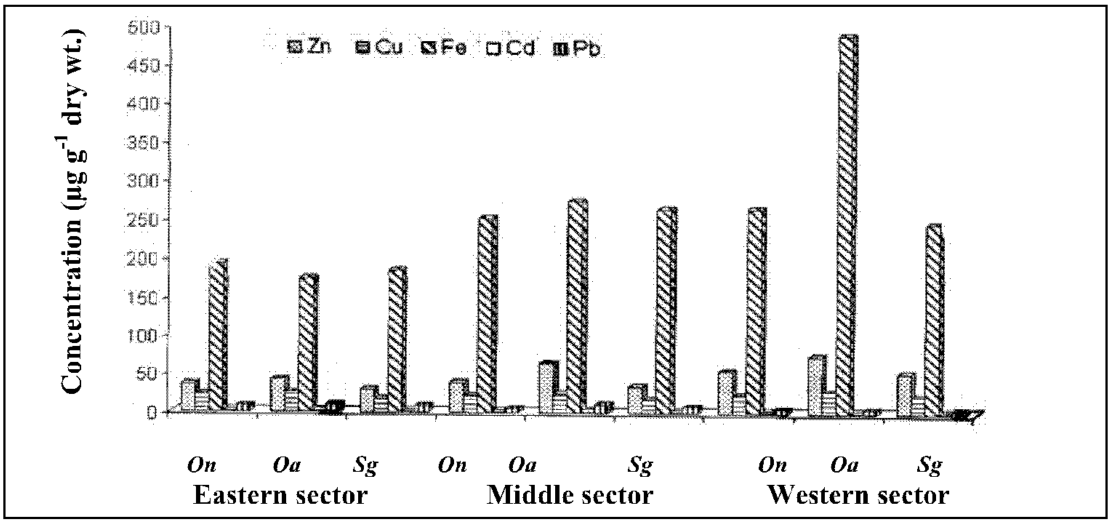


Fig. 9.11 **Annual means of heavy metals concentrations (μg g^{-1}dry wt.) in liver tissues of cichlid fish species collected from the three sectors of Lake Burullus during 2002 (Moussa 2003)**

Regarding the middle sector, no differences exist between the three species for Zn, Cu, Fe and Cd. However, Pb accumulation showed significant difference between *O. aureus* (10.13±1.12 μg g^{-1}) and *O. niloticus* (4.82±1.23 μg g^{-1}), but no significant differences exist between *S. galilaeus* (8.3 8± 1.96 μg g^{-1}) and the other two species.

Concerning metals accumulation in liver tissues of fish collected from the western sector, no significant difference was present among different fishes except Cd, where it showed a difference between *O. niloticus* and *O. aureus* on one side, and *S. galilaeus* on the other side. The minimum values of Zn, Cu, Fe, Cd and Pb were detected in liver tissue of *S. galilaeus*, with annual means of 52.78±14.17, 22.07±4.85, 246.9±55.7, 0.228±0.013 and 3.90±0.84 μg g^{-1}, respectively. However, the maximum values of these metals were determined in *O. aureus* with annual means of 74.45±22.71, 28.43±3.93, 470.76±131.88, 0.483±0.036 and 5.34±1.10 μg g^{-1}, respectively. From Table 9.18, it is clear that *O. niloticus* showed no significant differences among the three sectors for all metals, whereas *O. aureus* showed significant difference between the eastern and middle sectors on one side, and the western sector sectors on the other side for Zn, Cu and Fe. However, there is a significant difference between the middle sector and both of the eastern and western sectors, and between the western and eastern sectors for Cd. *S. galilaeus* also showed a significant difference for Pb between the eastern and western sectors on one side, and the middle sector on the other side.

For the whole lake, metals in liver tissues were accumulated in the order of Fe> Zn >Cu > Pb > Cd with an annual average of 260.89, 47.18, 22.45, 7.06 and 0.53 μg g^{-1} (Table 9.18). *0. aureus* accumulated more metals than the other two species. The annual average was 81.81, 61.78 and 59.28 μg g^{-1} for *0. aureus, 0. niloticus* and *S. galilaeus,* respectively.

9.3.4. Fishing Effort Analyses

According to the statistical data, it is clear that the number of licensed fishing boats and fishermen had remained relatively constant during the past period up to 1984. Starting with 1985 and the following years, the fishing efforts have been considerably increased in order to coincide with the considerable increase in fish yields obtained during these last years. The number of fishermen has increased from about 9000 men in 1963 to about 21660 men in 1993, then to about 28000 in 2002. The number of boats has increased from 2438 boats in 1963, to about 7277 in 1993, and to 10489 boats in 2000. The annual catch per fisherman has been nearly doubled from about 0.8 ton in 1963 to about 2.0 ton in 1993 then decreased to about 0.9 ton in 2000. Likewise, the catch per boat has been doubled from about 3 ton in 1963 to about 6 ton in 1993 then decreased to about 5.3 ton in 2000.

Statistical analysis of production functions, revealed that the total catch of the lake is positively correlated with the total number of boats and fishermen. This interdependence, between catch and fishing effort, is largely responsible for the variations in fish yields from year to year. This can be explained as follows: when the fishing intensity increases, the fish population begins to deteriorate, fish yields decline and fishermen respond by decreasing their effort until the fish stocks are built up again. As the fish stocks increase, an increase in fishing effort follows, which after certain period again reduces fish stocks, fish catch, and returns of fishing. This oscillating behavior of fishing effort and fish catch indicate that the intensive fishing effort is over-exploiting the fisheries, reducing the actual yields below the optimum sustainable yields. That what happened during 1970's; land reclamation have forced the same number of fishermen to intensify fishing effort on the remaining lake area, that led to depletion in fish stocks of the lake, followed by reducing its annual yield. Therefore, regular surveys should be made in order to follow further variation in the fishing effort and its effect on the fish stocks.

9.3.5. Fishing Gears and Techniques

El-Maghraby *et al.* (1977) described the fishing gears in Lake Burullus and classified them according to their way of capturing the fish. The gears given here are only the most popular types, which are of common use in Lake Burullus and other Northern Delta Lakes.

I. Entangling Gears:

1. Gill net
2. Trammel net (*Nasha and Takem*)
3. Stationary trammel net (*Saksook*)

II- Encircling Gears:

1. *El-Gafsha*
2. *El-Ganeb*

III- Trawl Gears (Dragged gears).

1. *Lawat*
2. *Lokkafa*
3. *Kerba*

IV- Seine nets:

1. *Eshalta*

V- Set nets:

1. Shrimp set net
2. Mullet set net

VI- Traps:

1. Wire basket trap
2. *Fyke* nets
3. *Clarias* trap

VII- Hook and line Gears:

1. Baited and unbaited hooks

VIII- Cast nets:

1. *Torraiha*

IX- *Hosha*

9.3.5.1. Entangling Gears:

9.3.5.1.1. Gill net

The gill net is designed to capture fish by entangling them in the meshes. The size of the mesh is such as to allow the passage of the head but not the body of the fish. The fish is usually caught behind the gill covers (operculum). The size of the mesh varies according to the fish species desired to catch. By this means it is possible to allow for escapement of the under-sized fish.

The gill net is used to catch *Lates niloticus*, sometimes fishes of family mugilidae or tilapia. Fishing operation is carried out usually by night. The gill nets are usually manufactured of cotton twines No. 80/6 or nylon twines Td 210/3. Gill nets without floats and leads are mostly used to build weirs, fastened to bamboo sticks, mainly during migrations of mullets. They are also used for other special methods of fishing. The length of a part of gill nets varies between 10-20 meters; the height between 30 and 160 cm, and the number of meshes per 50 cm varies from 14 to 26.

9.3.5.1.2. Trammel net

This is the most common net in Lake Burullus, and is used to catch various fish species including tilapia, mullets and others. A trammel net consists of three layered walls of webbing. These are hanged from a single cork and lead line. The two outer walls are made of cotton twines (No 80/6) or nylon twines (Td 2l0/3 or 110/3). The inner wall having smaller stretched mesh made of cotton twines (No 120/6) or nylon twines (Td 210/3 or 110/2). The mesh size of both the inner and outer walls depends on the species and size of fish to be caught.

Fish are captured by passing between the large meshes of the outer wall, then pushing the small meshes of the inner wall into a pocket between the large meshes of the wall on the opposite side of the net. When the trammel net is hung, care in taken to make the inside web quite sufficient, so that there will be a plenty of webbing to trap the fish. The stretched length of the central wall equals usually from 1.5 to 2.0 times the stretched length of the outer wall. Three meshes of the central wall are usually connected with one mesh of the outer

layer in the longitudinal direction. If the inside wall of webbing is not hung properly, after few fish are captured the netting will be drawn so tight that it has no room for others to be entangled. The lead rope is longer than the cork rope, so that the pockets are easily formed.

This gear is used with difficulty in some areas and seasons because of the prevalence of crabs or aquatic plants (*Ceratophyllum demersum*) which entangle the net and render it difficult to remove. The local name given by the native fishermen to the trammel nets used in Lake Burullus is El-Naama. This net is used in different ways. The basic part of the net is some 25 meters long, 75cm height. These basic parts can be fused to make a net of the desired length.

When a likely fishing spot has been found, the boat is anchored. Two boats usually operate for fishing with this net. In operation of the set, the fishermen join their nets and row away from each other, allowing the net to fall. The nets are set so that they form a closed oblong pattern or any number of other patterns in the water, which enclose the major portion of the school and prevent the fish from escaping. The fishermen strike the water on the bottom of the boat repeatedly to enforce the fish to enter into the nets. After a short period of time, depending on the school of fish, length of the net and other conditions, the gear is picked up and the catch is removed from the net. This fishing operation may take few hours if the catch is large.

Trammel net is used as an entangling floating net, when set from a boat in the littoral part of the lake among the vegetation. The nets are marked with buoys and also flags on bamboo poles, so as to be visible from quite a distance. The net is set overnight; the fish caught in the net are removed several times while the net is left setting. A common type of this net is called locally by fishermen as "Takem" which is adopted for use in deeper water (Fig. 9.12). It is some 1.25 meter in height and is set from a boat. It is used in the deeper western part of the lake. Another type called Nasha is specially used to catch *Tilapia* spp. In this net, the length of the basic part is some 20 meters, the height is 60 cm, the outer layer has 10-14 meshes per 50 cm, while the inner one has 14 to 20 meshes per 50 cm.

Nets of various colours are used according to the water turbidity and season of the year. Nets are usually treated by various colouring materials to suit the water turbidity and fishing time of the day (Fig. 9.13).

9.3.5.1.3. Stationary trammel nets (*Saksook*)

Saksook (Fig. 9.14) is a modified type of trammel nets used in Lake Burullus The net consists of three layers, usually manufactured of nylon similar to those used for making the ordinary trammel net.This net is designed so as to increase the catch ability of the net. Dry bamboo sticks are fixed to the upper rope of the net at regular distances. This keeps the net suspended in the upper 40

cm of the lake water. It is well known that this type of framed net is called beamed trammel net; that is more efficient than the ordinary gill or trammel nets. The height of the net hardly reaches 50 cm where lead pieces are attached to the lower rope and several pieces of the net are joined together constituting a set of 400 meters long. The net is usually set at right angles to the shore or in a strait between two islands. This net is used mainly in Lake Burullus to catch mullet, therefore its use is confined to the season of mullet spawning migration. One can find several nets of this type set in the area at lake-sea connection. It is interesting to mention that the catch can be removed several times, while the net is left setting.

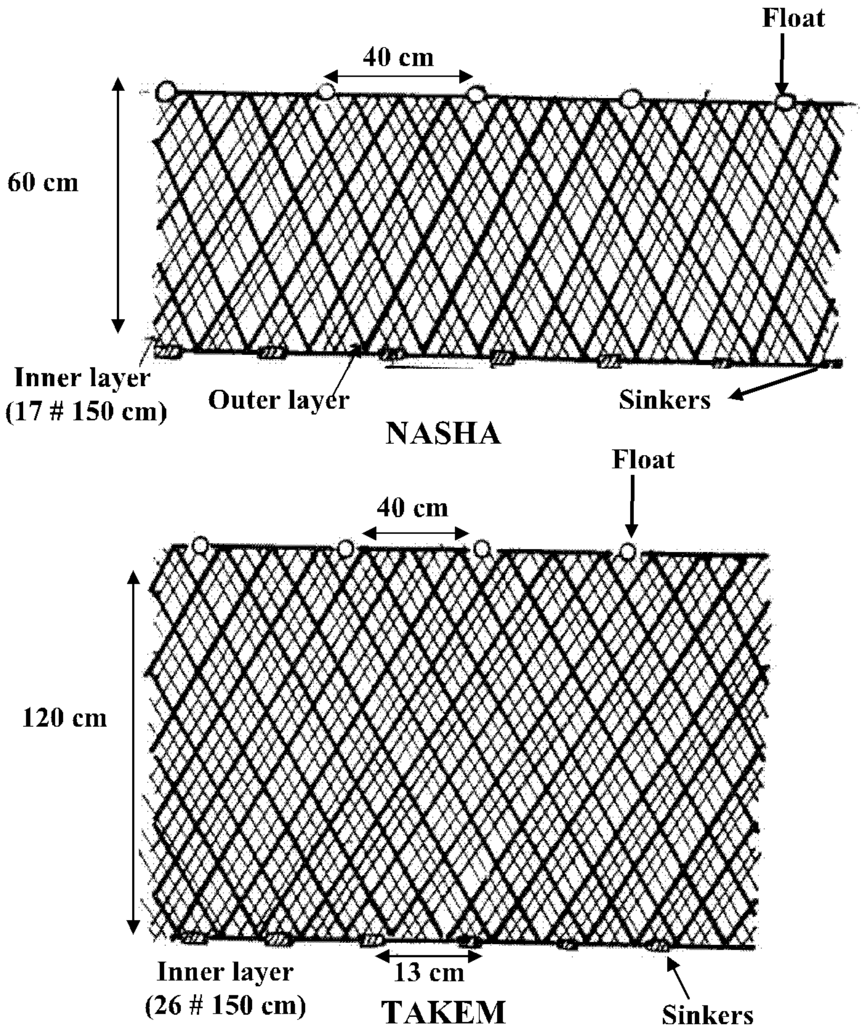


Fig. 9.12. **The two common types of trammel nets used in Lake Burullus (El-Maghraby *et al.* 1977)**

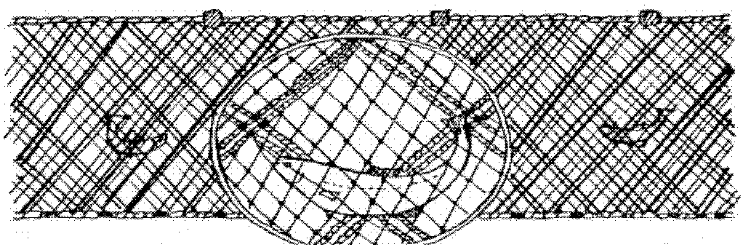


Fig. 9.13. **A section of trammel net showing the pocket formed by trapped fish (El-Maghraby *et al.* 1977)**

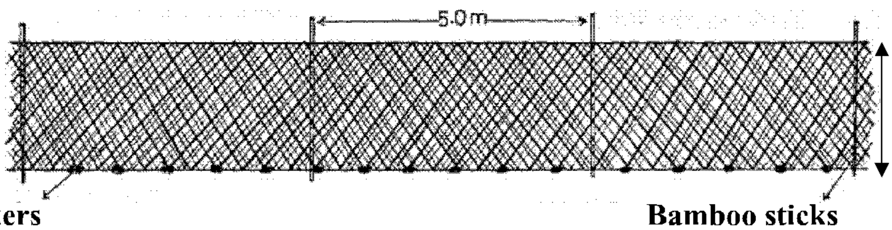


Fig. 9.14. **Fixed trammel net (Saksook) (El-Maghraby *et al.* 1977)**

9.3.5.2. Encircling gears

9.3.5.2.1. El-Gafsha (Shebak El-Habl)

El-Gafsha is the largest of all nets used in Lake Burullus. The net is about 500 to 1000 meters long, 4 meters height, without floats and weights. The net is usually manufactured of cotton twines No. 20/4. The webbing is treated sometimes with traditional preservative against rotting. It has 30 mesh bars per 50 cm at the middle portion of the net, which decreases to 26 towards the ends. Such a net requires about 30 persons to operate. Each man holds a length of 6 to 10 meters, these being joined together to form the complete net.

This sort of net is used in shallow waters; and is coiled up in the stern of a large fishing-boat in two equal portions, each resting on small rafts, generally made of dried stalks of reed bound together. When the boat is in position, the rafts are floated out at the stern, one at each side, and the net which is attached to the boat by a strong cord, is payed out in a semi-circle. The upper edge of the net is kept 60 cm above the water, by boys, who hold the net with short stalks of bamboo. The lower edge is kept touching the bottom by their feet.

In this way, the encircled fish (specially mullets which are excellent jumpers) are prevented from escaping either by jumping the upper head rope or by running under the lower edge of the net. When about half of the net has been payed out, several boats, which have taken up their position some distance behind the chief boat, begin working towards the net, while shouting and beating

the water in order to drive the fish in front of them. The fishermen operating the net also keep up shouting, while their chief is directing the operations from the large boat. When the net is all payed out, the two ends are gradually brought together, the large boat being pulled ahead to keep the top edge of the net fairly tight. Directly after the two ends are closed, the boys holding up the net meet in the middle line and keep the two edges close together, preventing the fish from jumping out. The net is then hauled on the large boat, and after the contents have been shaken out into the hold, it is carefully coiled back onto the rafts ready for use again. One fishing operation takes about one hour. This net is operated in summer to catch mainly mullet; while fishing is carried out on day time. Sailing for fishing starts at sunrise, while the boats return at sunset.

9.3.5.2.2. *El-Ganeb*

The complete net is made up of sections, each of about 15 meters long and 1.5 meters wide attached together. The webbing is manufactured of cotton twines No 20/4. The upper and lower ropes are not furnished with floats or sinkers. Two or three small boats operated with about 8 fishermen are engaged in fishing by this net. Fishing is carried out in shallow areas covered with aquatic vegetation. A well trained fisherman goes around to beat the water with bamboo stalk. Movement of fish in the area is then observed, indicating the size of fish shoals. Once a considerable shoal of fish is detected, a fishing spot is fixed.

The fishing operation starts by setting the net, fixed by stalks surrounding the aquatic plants; a small part of the net is left opened. When the net has been set out, several men start from some distance off and advance towards the opening, shouting and beating the water so as to drive fish to the surrounding area, to ensure a better catch. Shouting is usually more efficient in areas of clear water. The next step is to enclose completely the aquatic plants by closing the opening. Four or five fishermen drive inside the enclosed area, cutting and removing the plants out from it, meanwhile closing the net gradually. Step by step the fish are traped inside the net and are then removed out from it. El-Ganeb net is operated usually for fishing *Clarias* fish.

9.3.5.3. Trawl gears (Dragged gears)

9.3.5.3.1. Lawat

Lawat (Fig. 9.15) is a big trawl net used in Lake Burullus. This net consists of 180 to 200 meters netting, 8 meters height at the middle decreasing to 4 meters at the ends of the net. The net has 35 mesh bars per 50 cm at the middle portion, decreasing to 30 at the wings. The netting is manufactured of cotton twines No 20/4 or No 50/9, treated with cutch for preservation. Cork pieces are hung to the upper rope while lead is hung to the foot rope.

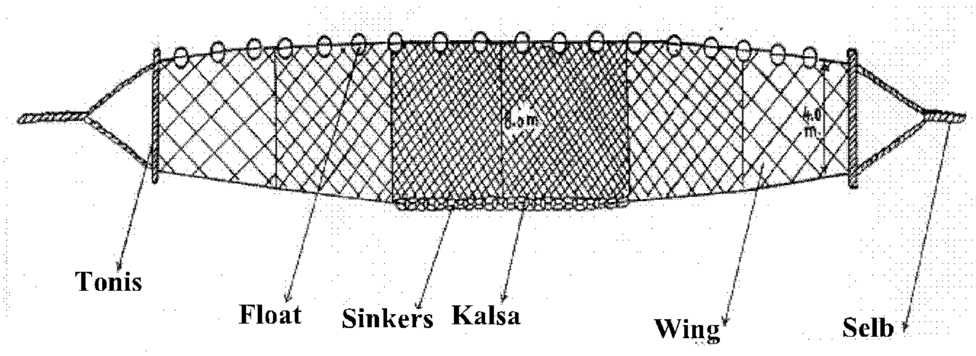


Fig. 9.15. **Sketch of Lawat or Wannan net (El-Maghraby *et al.* 1977).**

The net is towed by two boats, each carries half the net. When the fishing operation starts, the two parts are joined. The center of the net is dragged on the bottom by a pole burdened by a rock or heavy iron chain. It is important to keep the bottom line close to the ground so as to prevent the escape of fish. The time of trawling depends on both the speed of wind and abundance of fish. The net is more or less dragged for about one km distance. The trawling is only possible when the wind is satisfactorily strong. After trawling, the net is lifted on the two boats and catch is removed. Once a fishing operation is completed, the two boats sail to a next fishing spot. Fishing with this net is usually carried out at day time; starting by sunrise and returning at sunset. All types of abundant fish are caught by this net.

9.3.5.3.2. Lokkafa

Lokkafa (Fig. 9.16) is a sac-like funnel shaped net, some 8 meters long, fastened to a wooden frame shaped like a reversed "V". It is manufactured from cotton twines No 20/9 and sometimes of nylon twines Td 210/8. The wooden frame is made from a couple of curved wooden stalks, each measures about 3 meters long, and fastened together to form a "V" shape. A wire of about 120 cm. long is fastened between the ends of the two wooden pieces, forming the base of the triangle. The netting has 30 mesh bars per 50 cm. at the edges of the sack. The number of meshes diminishes gradually towards the ends of the funnel, reaching 80 meshes.

This net is tied to the side of the boat and is thrust nearly vertically into the water, and dragged by the boat, consequently any fish that may be enclosed falls back into the net. The net is lifted usually after half hour trawling. More catch is obtained at dark stormy nights. *Lokkafa* is not selective for certain fish species.

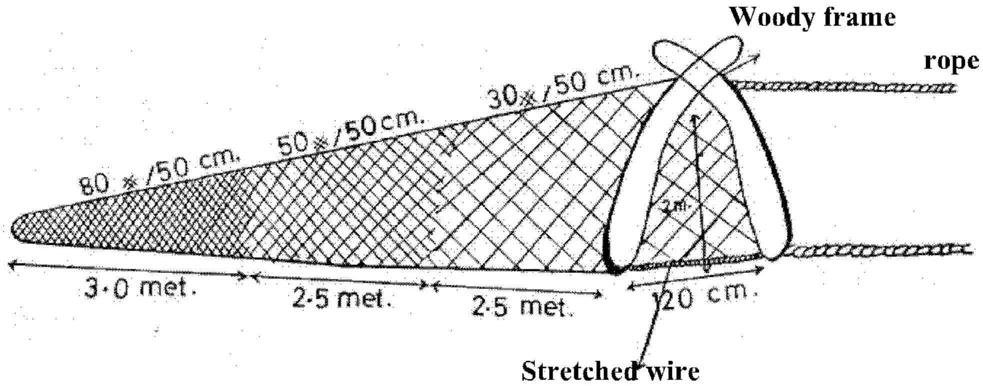


Fig. 9.16. **Small trawl net (Lokkafa) (El-Maghraby *et al.* 1977).**

9.3.5.3.3. El-Kerba

This net (Fig. 9.17) is more or less similar to *Lokkafa*, but smaller in size, with a modified wooden frame. The wooden frame is triangular in shape. A sharp iron plate 90 cm. long, constitutes the edge of the base of the frame. The "V" shaped piece is strengthened by cross bars. To the frame, a funnel shaped webbing about 6 meters long is attached. The funnel webbing is usually manufactured of nylon twines Td 210/6 or 210/9.

El-Kerba is tied to the side of the fishing boat with a strong rope. Fishing with this net is carried out in areas where aquatic plants are spreading. When trawling, the net is held by the fishermen themselves, where they push the wooden frame downward, cutting the plants by the sharp edges of the frame. Consequently, these plants as well as all fish living within the plants fall back into the funnel of the net. The net is then lifted on the boat where the catch is removed and plants thrown away. Fishing with this net is carried out at night; stormy nights are occasionally preferred, when more catch of various fish species is obtained.

9.3.5.4. Seine net (*El -Shalta*)

El-Shalta is of the common type of seine nets used in the lake. The length of the net is around 10 meters. The upper rope is furnished by cork pieces as floats; the lower rope carries pieces of lead. The webbing is manufactured of cotton twines No 20/4, usually treated with seed oil as net preservative. The webbing has 40 meshes per 50 cm. There are poles tied to the ends of the net. This net is commonly used for hauling towards beaches. Two or more fishermen usually haul with this net.

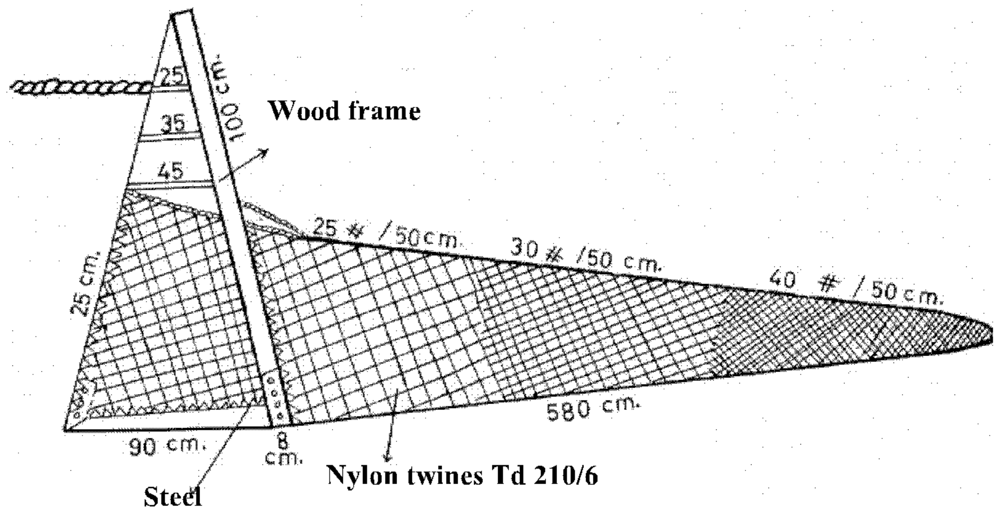


Fig. 9.17. **El-Kerba net (El-Maghraby *et al.* 1977)**

9.3.5.5. Set nets

9.3.5.5.1. Shrimp set net

Shrimp set net consists of two parts, a weir (fence) and a catching box. The weir is formed by three to four sections, some 20 to 30 meters long, each of one meter deep, 35 mesh bars per 50 cm. The net is fixed on bamboo stalks. The catching box is placed at the end of the weir. It is 10 to 15 meters long, 1.25 meter deep and has 45 meshes per 50 cm. It has a semicircle or semiellipse shape. The weir ends in the middle of the catching box. The ends of the semicircle turn back and lead close to the weir into the middle of the box. In such a way, two narrow slit entrances are formed on both sides of the weir. In one setting, usual ly three weirs and six catching boxes are present.

9.3.5.5.2. Set net for mullet

This type is used in the lake-sea connection area, mainly at the time of mullets migration. The net has two parts; the weir as that described in shrimp set net and the catching box composed of trammel net which is spirally turned. Another trammel net is fixed just outside the labyrinth above the water surface to capture those fish which try to jump over the wall of the box.

9.3.5.5.3. Mugil capito set net

This type is used during the spawning migration of *Mugil capito* towards the sea (October till December) in the lake-sea connection area. It is formed of a weir fastened to bamboo stalks. The height of the net is 175cm, the webbing has 35 mesh bars per 50 cm. The weir ends in spiral like turnings (three full

turnings) of the catching box. In the middle of the labyrinth, there is a catching chamber. Besides, the box is provided with three to four back wings.

9.3.5.6. Traps

9.3.5.6.1. Wire basket traps

The wire traps (Fig. 9.18) used in the Egyptian Delta lakes are of non return basket type, made of galvanized wire webbing 0.8 mm diameter. A typical trap has one hoop, horizontally elliptical, 100 cm long and 50-60 cm in diameter. The meshes are hexagonal and the weirs are tripple twisted at the junctions. The cone at one end of the trap has an elongated and vertical opening for the passage of fish. The blind end has no hoop and the catch is removed through an opening which is closed by a clasp.

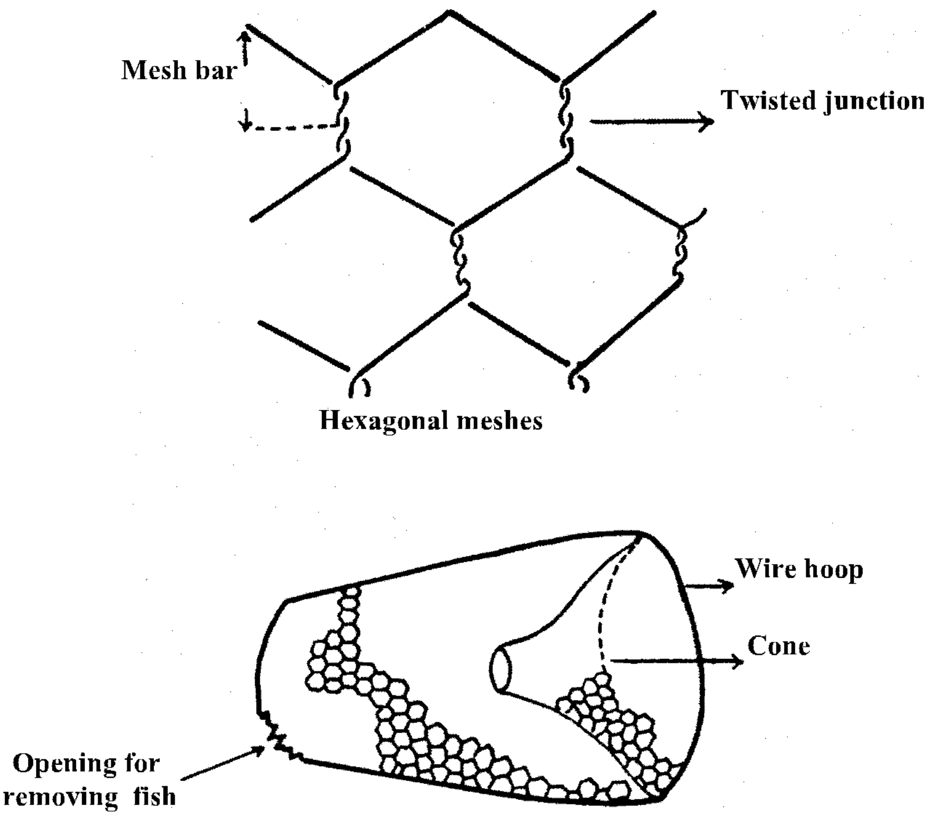


Fig. 9.18 **Wire basket trap (El-Zarka *et al.* 1970)**

These traps are usually set among aquatic vegetation, such as *Phragmites, Potamogeton* and. *Ceratophyllum* beds. In open water free from vegetation, the traps are either fixed to the bottom by bamboo sticks or in rows among an artificially made barrier. The barrier is usually made from bamboo sticks with gaps at intervals into which the traps are placed.

The traps which are very commonly used to catch mainly *Tilapia,* may also catch mullet fishes. The mesh bars of the traps usually range from 14 to 30 meshes in 50 cm. On the other hand, the traps are used to catch fishes which are traped behind an artificial muddy barrier. Traps with relatively narrow meshes are set in openings through the muddy barrier.

9.3.5.6.2. Clarias traps

Clarias traps (Fig. 9.19) are used to catch *Clarias* fishes, during their spawning season. This net is considered to be a complicated mode of fishing methods. The whole net consists of three traps joined together and the net is set between two banks of a freshwater stream; traversing the water flow. It is well known to the fishermen in Lake Burullus that *Clarias* fish move towards the fresh water during the spawning season. They usually prefer swimming near the banks of the stream.

The webbing is made from cotton twines No 20/8. The wings of the traps are fixed by dry bamboo sticks, about one meter height. Each trap is fixed also between two sticks. The number of sticks used depends on the velocity of water flowing. Before setting up the net, the muddy bottom is piled up in the form of a dune. The sticks are fixed in this muddy dune in a way that the dune, touches the mouths of the three traps. This dune serves as an underline for the mouth of the trap. The fishes while moving on the muddy bottom enter through the mouth of the trap to the cone.

Fishing with this net is carried out during night, where the net is fixed daily just before sunset and the catch is removed before sunrise. The net is left up for removing the catch, cleaning and drying during day time.

9.3.5.7. Hook and line gears

Line fishing is carried out at Lake Burullus, using baited or unbaited hooks; the hooks are made of iron. The first type is represented by a line carrying small hooks that are attached to the line by means of a 50 cm long cord, at distances of about 5 cm. Small fishes serve as bait. A line has some 500 to 600 hooks. Another type of line is provided with bigger hooks which are unbaited. This type in adapted for fishing on softly-bodied fishes like *Bagrus bajad* and *Clarias* sp. The lines are usually laid down at sunset and picked up again at sunrise, when they are dried by being coiled on pools.

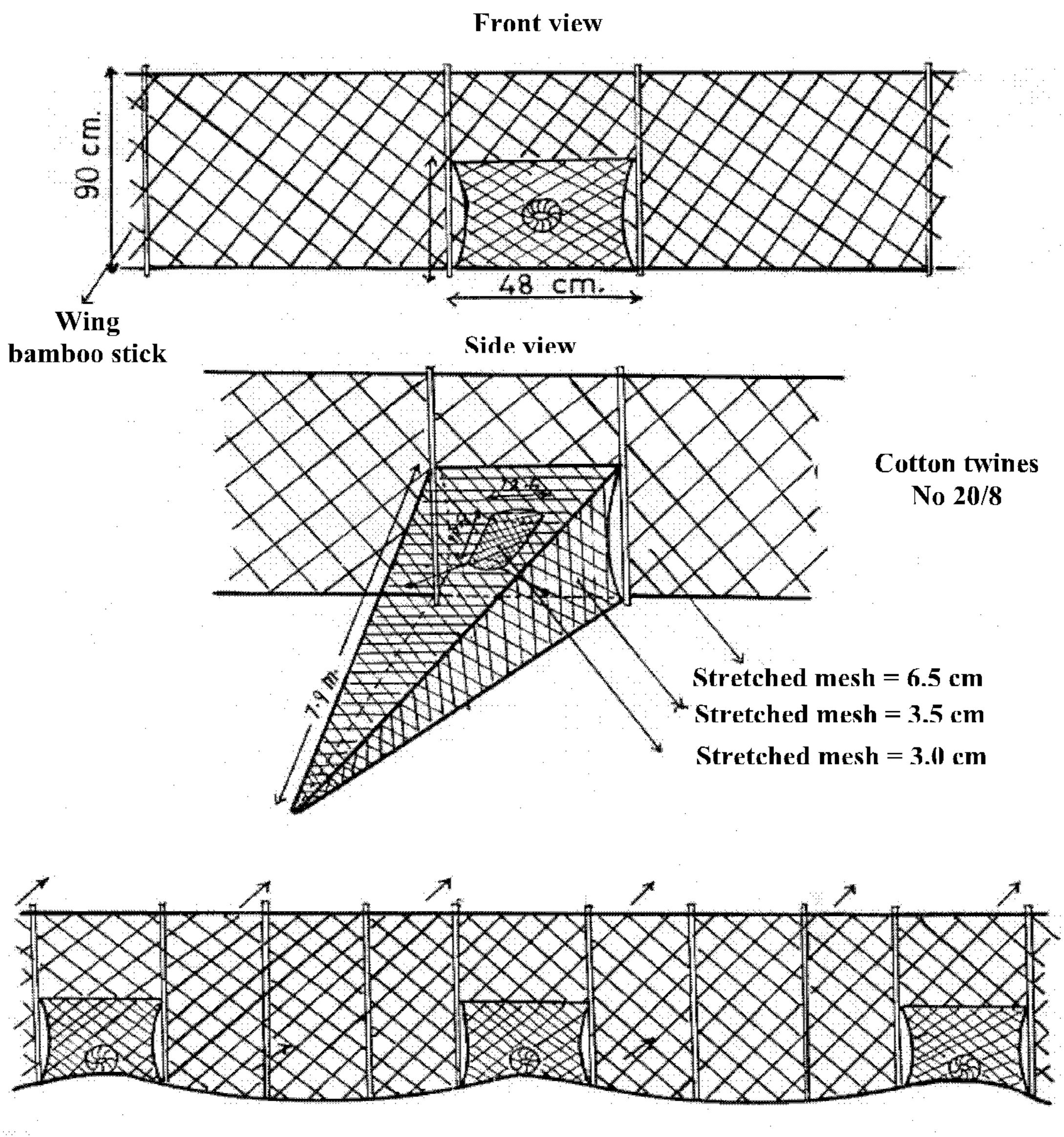


Fig. 9.19 Clarias **trap (El-Maghraby** ***et al.*** **1977).**

9.3.5.8. Cast nets (*Torraha or Shabka*)

Torraha is a circular throwing-out, with an average circumference of about 15 feet and has about 30 mesh bars in 50 cm. The net webbing is manufactured of cotton twines No 20/9, sometimes of Nylon twines Td 210/6. A

strong cord is attached to the middle of the net and a thin cord runs around the circumference. To the latter cord leads are attached about 8 cm apart and it is looped up at each 50 cm to the inside of the net, at a height of about 15 cm, thus forming a series of pockets in which the fish otherwise entangled in the meshes get caught. Fishes with the exception of very large ones, rarely escape under the edge of the net.

The net is used in the following manner; the cord and the middle portion of the net to which it is attached, is gathered up in the right hand, half the net now hanging down in front of the fisherman. The fisherman is now ready to make a cast, and firmly planting his feet on the ground he turns the upper part of his body away from water and then swings smartly back again, releasing the net from his left hand.

If the net is properly thrown, it should fall on the surface of water in more or less complete circle. The net is now allowed to sink on the bottom and is then carefully drawn in, the fishes are taken out and the water squeezed out of the net, which is gathered up for a fresh cast. Before casting, the fishermen sometimes throw in a large stone or strikes the water with a stick, this often has the effect of attracting fish to the spot, on which casting is carried out.

9.3.5.9. *Hosha*

It is an enclosure located within the lake area (mostly at the southern shores of the lake, as well as around some islands). It is a pond represented by shallow water basin built by erecting low dykes made of mud and straws. It has one or more narrow openings connecting it with the lake. Fish swim into the *Hosha* through these openings, which are periodically closed. Then the Hosha is pumped dry and the fish are harvested. This fishing method may be repeated several times during the year, the bulk of the yield consists of small, low value cichlid species.

In 1982, there were 171 licensed *Hosha* in Lake Burullus (i.e. presumably modified with fish culture practices). *Hosha* operations occupy 12,689 ha (28,838 feddan). Of these, 45% were 1-42 ha in size , 28% were 42-84 ha, and a further 12% were 84 -126 ha. The remaining 15% were of operations 126-420 ha in size. Interestingly, Lake Burullus Area Development Study found that, in addition to the 171 licensed *Hosha*, there were an estimated 1,079 unlicensed or illegal Hosha in lake Burullus. Together the total estimated Hosha area amounted to 17,522 ha (39,822 Feddan), i.e 38% more than that officially licensed. While the officially licensed *Hosha* averaged more than 74 ha in size, the unlicensed *Hosha* average only 4-5 ha. It is estimated that Hosha operations with fish farms occupy an area nearly 1/3 the size of the open water area .

The studies revealed also that *Hosha* yields per ha are much higher than yields per ha from open lake fishing. On the average, Hosha produces nearly

two times the yield per ha produced in the open lake (0.970 ton per ha as compared with 0.541 ton per ha).

The fishermen consider *Hosha* as a negative factor, focusing on the competition for the same stock of fish and the competition for fishing areas. Furthermore, fishermen believe that Hosha reduces the production potential of the lake, primarily because it harvests all age groups. Some *Hosha.* particularly in the tilapia grounds of Lake Burullus's southern sector, produce small-sized fish (less than 6 cm) which are used for production of poultry meal. The proportion of small fish in the Hosha harvest ranges from 15% to 30%.

The long standing arguments against *Hosha* that it reduces important inshore breeding grounds and that it indiscriminately harvests fish of all sizes and thus (harmfully) removes juveniles from the potential breeding population may have had some validity prior to the construction of the Aswan High Dam. However, the change to a more freshwater environment has weakened both criticisms. First, the new water regime has resulted in aquatic vegetation and the accompanying tilapia breeding areas spreading throughout the lakes. Thus, the preservation of these inshore areas is now less important. Furthermore, the spread of aquatic vegetation has rendered much of the shallow shoreline unsuitable for open water fishing gears. Second, the change to a higher yielding fishery much dominated by tilapia, means that increased fishing pressure and thinning of juveniles may help diminish the problems of over-recruitment of tilapia. In addition, it is likely that Hosha's periodic drying of the bottom sediments will stimulate the recycling of nutrients, thus contributing to the overall productivity of the fisheries. This has been confirmed by many reports by algal blooms in newly flooded *Hosha* .

9.4. MAIN THREATS TO FISHERIES OF LAKE BURULLUS

1- Neglecting of clearing and dredging the lake-inlet to the Mediterranean is the first complaint of fishermen. The only remaining Burullus inlet near Burg El-Burullus is not dredged at regular basis. Decreasing of salinity levels have damaged the fish habitat and nursery of some marine high – valued fish.
2- *Hosha*, an illegal method of fish catching is widely practiced in lake Burullus, that harvests all sizes of fish that certainly affects the fish production of the lake.
3- Illegal capture of small fishes and fry directly from the only existing inlet by illegal operating gangs to provide fish farms established on the southern shore of the lake.
4- Using illegal fishing gears with small meshes leads to catching non-commercial sizes, which are finally dried up and used in feed industry. This certainly affects negatively upon the net fish production of the lake.

5- Hydrological and water balance studies revealed that the drainage water has dominated the lake ecosystem, and the water inflows into the lake are always greater than outflows. That means water in the lake is in a continuous movement toward the sea, and salinity has been reduced in the lake, which undoubtedly is reflected upon the disappearance of marine fish species from the lake.

6- Pollution and waste disposal:

Agricultural drainage. Agricultural drainage water with increasing quantities of fertilizer and pesticide loads are being released into Burullus, contributing significantly to the eutrophication and pollution of the lake.

Municipal wastewater. Untreated wastewater from Baltim and the villages outskirting Lake Burullus is directly released into the Lake. This has led to the rapid eutrophication of parts of the Lake and further promoted the extensive growth of *Phragmites australis* beds. Also, the drainage of toxic and industrial wastes into the lagoon eradicated some sensitive fish stocks and tainted the water; even some of the fishermen suffered from skin diseases.

Solid waste dumping. Solid waste is one of the main sources of environmental pollution associated with human settlements in Egypt today. Currently, there are no mechanisms or facilities to deal with solid waste in the sector.

7- The low awareness of fishermen about environmental issues as well as management plans and their importance, combined with limited understanding of the role of protected areas and their value (at both local and national levels) are some of the basic factors, which hinder the proper fisheries management of Lake Burullus and threaten their integrity in the long run.

9.5. RECOMMENDATIONS FOR FISHERIES MANAGEMENT

1- Economically, the main activity in Lake Burullus Protectorate is fish production, where the population majority declared that their income source comes from fishing. Therefore, fisheries activities must have priority in developing the population standards because this is the first step for sustainability.

2- It is essential for the preparation of the fisheries management plan that it includes the interests of Governmental (The local branch of the General Authority for the Development of Fisheries Resources: GADFR/Ministry of Agriculture) as well as other national agencies (Conservation Organizations and Development Agencies. A supplementary participation of local people in management efforts is needed, because when the local inhabitants feel part of development and progression, then the conservation organizations can be sure that the protection and management of the wetland is guaranteed.

Therefore, wide steps should be taken to promote the public awareness towards understanding the management and protection of natural resources.

3- At the initial stage of the management and monitoring process, a baseline data need to be established, to serve as a starting point, with which subsequent monitoring results are compared. Some of the results of the current site studies could be used as a basis for the Burullus baseline data.

4- Obtaining regular data on fisheries from local fisheries authorities (High priority). It is particularly important to collect accurate information on the economic value of the fisheries and fish production in the Protected Area. This information will be very useful in determining and evaluating fisheries management options in the Protected Area.

5- The water inflow of the agricultural drainage canals into the lake should be examined regularly to control polluted water inflow into the lake.

6- Removal of solid wastes from lakeside; either by re-allocation of these wastes away from lake water to a more environmentally acceptable area or constructing a plant for recycling these wastes; in addition to raising public awareness to discourage littering.

7- Restoring the natural status of the lake by addressing Baltim's sewage waste problem, by liaising with the National Agency for Drinking Water and Sanitary Wastes to construct the sewage treatment plant through the local advisory committee.

8- Monitoring the lake water level and salinity through an adequate management program to control the quantity of drainage water inflow into the lake.

9- Fish farming is becoming a prominent activity along shores of Lake Burullus, occupying increasingly large areas, and their total production in 2000 was about 115,335 tones, i.e. more than twice of open water production. They are often attracting large numbers of waterbirds and other wildlife. There is a need to assess the ecological value of aquacultures in the region as alternative wetland habitats, and the effect that various management procedures applied have on that value. The study should propose ways which maximize benefits to both fisheries and wildlife.

10- Illegal fishery practices should be banned, such as capture of fry and small fishes from the sea inlet area, "Hosha" fishing procedure, and using illegal fishing gears with small meshes.

11- Fishery management of cichlid species must be based on the criterion of gaining extra fish weight, because the mean size of cichlid species in the catch of Lake Burullus does not affect their breeding activities, i.e. first maturity is usually attained at small sizes. By this procedure, the total catch

of cichlid species from the lake is expected to increase two or three times than that available today. It is suggested that the most effective method to attain such gain is the regulation of the mesh of fishing gears. So, it is recommended that the stretched mesh size of the trammel nets should not be less than 2.86 cm (or mesh number 17) to catch cichlid fishes of 15.0 cm mean selection length for either *Oreochromis niloticus* or *T. zillii*. For traps, it is advised that the mesh size of wire traps should not be less than 25 mm (mesh bar) to give a mean selection length of 16 cm for *0. niloticus*, 15.5 cm for *T. zillii* and 15 cm for *S. galilaeus*.

Based on the above, it is recommended that the minimum catchable size should be 15 cm, instead of the present legal size 10 cm. Consequently, this will increase the average weight of individual fish from 40 to 60 gm and hence the total fish yield.

12- Fishery management of mullet fishes is based on raising salinity of Lake water and regulating of a closed fishing season from December 20th to January 20th; the peak period of migration of juvenile mullets from the Mediterranean into the Lake.

9.6. SUMMARY

The occurrence of brackish and saline waters in Lake Burullus during seventies and early eighties of the last century, has resulted in a large variety of fish species inhabiting the Lake; approximately 32 species were recorded in the Lake during these periods. Decreasing of salinity and dominating of drainage water in the lake during the last two decades has led to change in species composition and biodiversity of fishes and other organisms. The field survey during 2000 – 2002 period showed that the diversity of fishes in Lake Burullus has declined from 32 to 25 species. All the species which have disappeared are of marine affinity. On the other hand, the total production of the lake has increased gradually from 7349 ton in 1963 to its maximum of 59000 ton in 2002. In the course of these forty years, a sharp decline in the total yield was recorded, especially in the middle of seventies, where the production declined to 4556 and 4875 ton in 1973 and 1974, respectively. Higher yields were regained in 1976 (6573 ton).

As far as the main groups of fishes are concerned, a gradual decrease in the mullet catch was recorded from about 44.7% in 1963 to 17% in 2000 of the total catch. This was accompanied by an increase of tilapia production from 42.8% in 1963 to 72% in 1992, and then decreased to about 67.8% in 2003. The shift was more pronounced during the eighties of the last centurry. On the other hand, the annual production of certain freshwater fish species has gradually increased, especially during the last five years. This relates to two species; *Clarias gariepinus* and *Bagrus bajad*, where their production increased from

188 and 220 ton in 1963 to 2150 and 744 ton in 2003, respectively. The production of marine fishes, such as *Johnius hololepidotus* and *Dicenlrarchus labrax* was greatly decreased. All these changes confirm an increased predominance of freshwater components in the fish stock of the lake, reflecting the changes that the lake underwent in the water supply, mostly from drains, and reducing chlorosity of water, especially in the eastern part of the lake in association with the huge drains newely constructed at that area.

Cichlids are represented in Lake Burullus by four main species which are *Tilapia zillii, Sarotherodon galilaeus, Oreochromis niloticus* and *O. aureus*. Besides, there are two species of cichlids, namely *Hemichromis bimaculatus* and *Haplochromis bloyeti* but these are of little economic importance due to their small sizes. It was found that *Oreochromis niloticus* was the most abundant species in the 2002 catch, constituting more than 40.5 % of the total catch, followed by *Oreochromis aureus* (34.7 %), while *Sarotherodon galilaeus* was the least frequent species contributing 24.8 %. In the eastern sector, *Oreochromis aureus* is the most commonly distributed one (38.5 %) followed by *Sarotherodon galilaeus* (31.5 %), then *Oreochromis niloticus* (30.1 %). In the middle and western sector, *Oreochromis niloticus* is the major one with 39.8% and 53.6 %, respectively. *Oreochromis aureus* represents 35.7 and 28.9 %, whereas *Sarotherodon galilaeus* is the minorly distributed with 24.5 and 17.5 % in the two sectors, respectively.

On the other hand, five species of mullets are present in Lake Burullus namely: *Mugil cephalus*, *Liza ramada*, *Liza aurata*, *Liza saliens* and *Chelon labrosus*. *Liza ramada* is the most dominant species of the mullet catch throughout the year. Its accessibility in the nets operating in the lake greatly increases during November and December, when the fish is sexually ripe. *M. cephalus* production ranks next to that of *L. ramada*. Its maximum yield is attained during summer, representing maturation period. The fishery of *Liza saliens* whose production comes next to that of *M. cephalus* extends from late spring to the beginning of autumn. The maximum fishing of this species is recorded in September, during which the fish leaves the area of the lake-sea connection, where it is localized and migrates to the sea.

According to the statistical data, the number of fishermen has increased from about 9000 men in 1963 to about 21660 men in 1993, then to about 28,000 in 2002. The number of boats has increased from 2438 boats in 1963 to about 7277 in 1993 to 10489 boats in 2000. The annual catch per fisherman has been nearly doubled from about 0.8 ton in 1963 to about 2.0 ton in 1993, then decreased to about 0.9 ton in 2000. Likewise, the catch per boat has been doubled from about 3 ton in 1963 to about 6 ton in 1993, then decreased to about 5.3 ton in 2000. Statistical analysis of production functions revealed that the total catch of the lake is positively correlated with the total number of boats

and fishermen. This interdependence, between catch and fishing effort, is largely responsible for the variations in fish yields from year to year.

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9.8. PLATES OF FISHES (9.1 – 9.15)

(after Bishai & Khalil 1997, Website: www.fishbase.org 2000)

Plate 9.1
Tilapia zillii
Oreochromis niloticus

Plate 9.2
Oreochromis aureus
Sarotherodon galilaeus

Plate 9.3
Clarias gariepinus
Lates niloticus

Plate 9.4
Mugil cephalus
Liza ramado

Plate 9.5
Dicentrarchus punctatus
Bagrus bajad

Plate 9.6
Anguilla anguilla
Liza saliens

Plate 9.7
Disentrarchus labrax
Sparus aurata

Plate 9.8
Solea solea
Atherina boyeri

Plate 9.9
Labeo niloitcus
Hydrocynus forskalii

Plate 9.10
Gambusia affinis
Barbus prince

Plate 9.11
Barbus bynni bynni
Aphanius fasciatus

Plate 9.12
Pomatoschistus microps
Haplochromis bloyeti

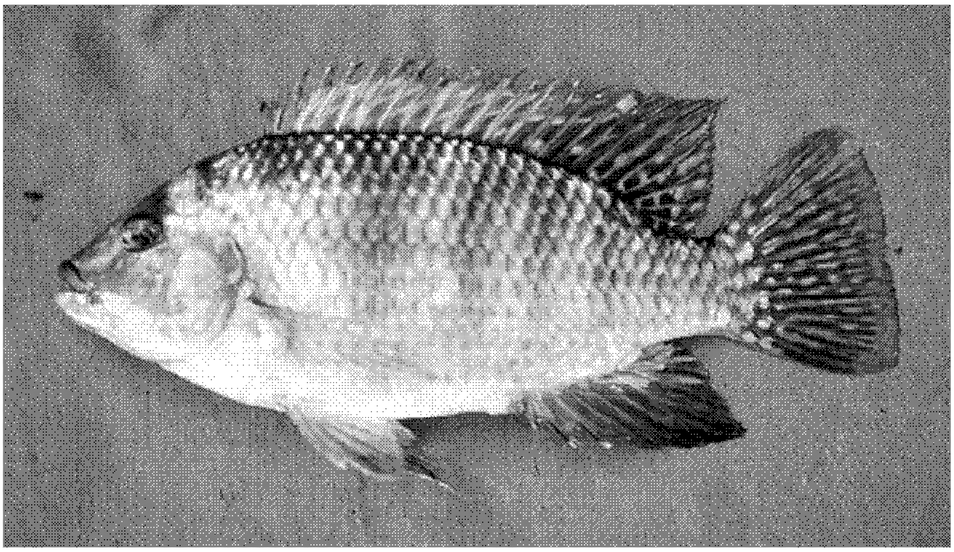
Plate 9.13
Hemichromis bimaculatus
Engraulis encrasicholus

Plate 9.14
Belone belone
Liza aurata

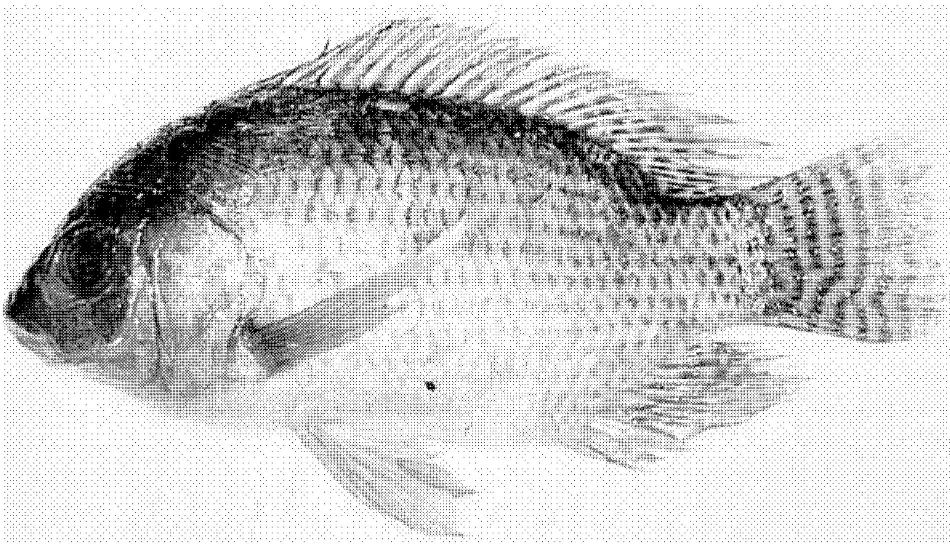
Plate 9.15
Chelon labrosus
Pomatoschistus minutus

Plate 9.1

1. Common species

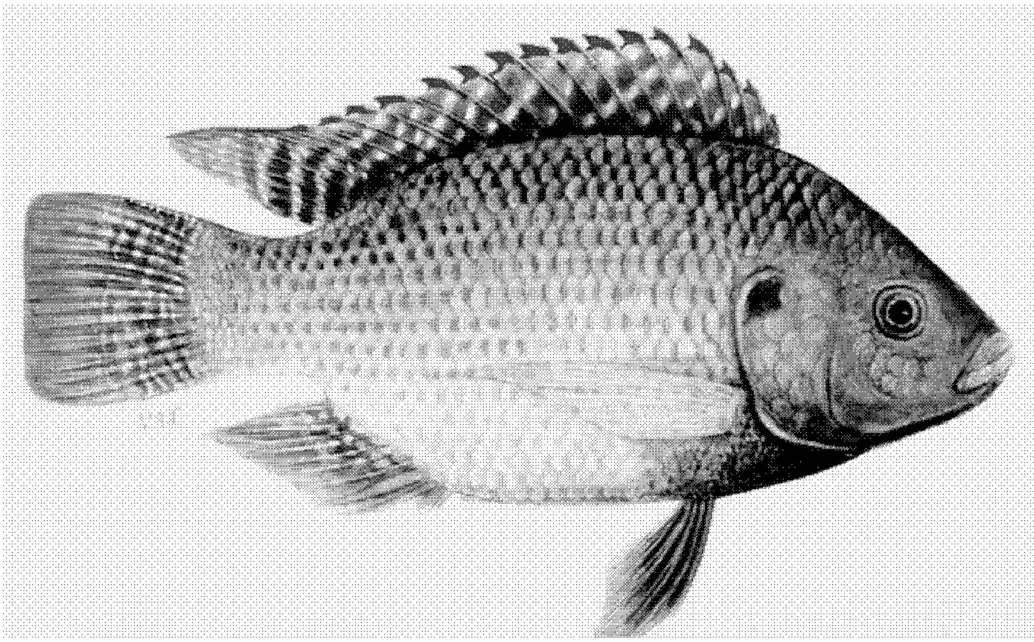


Tilapia zillii بلطى أخضر

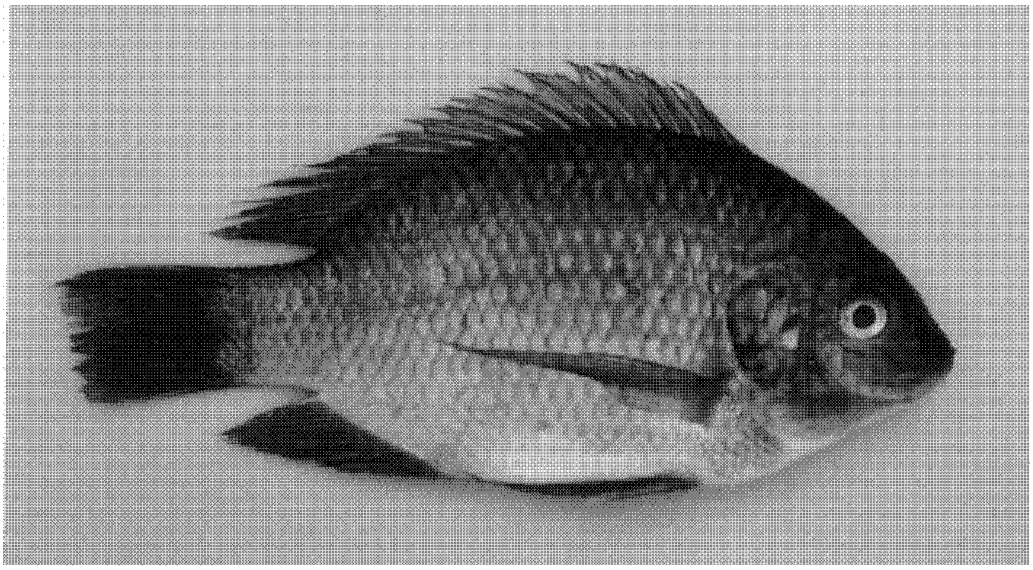


Oreochromis niloticus بلطى نيلى

Plate 9.2

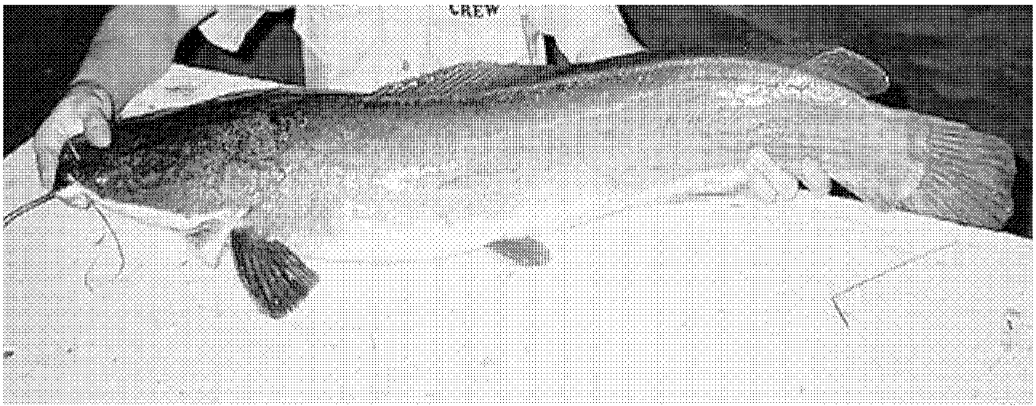


Oreochromis aureus بلطى ازرق

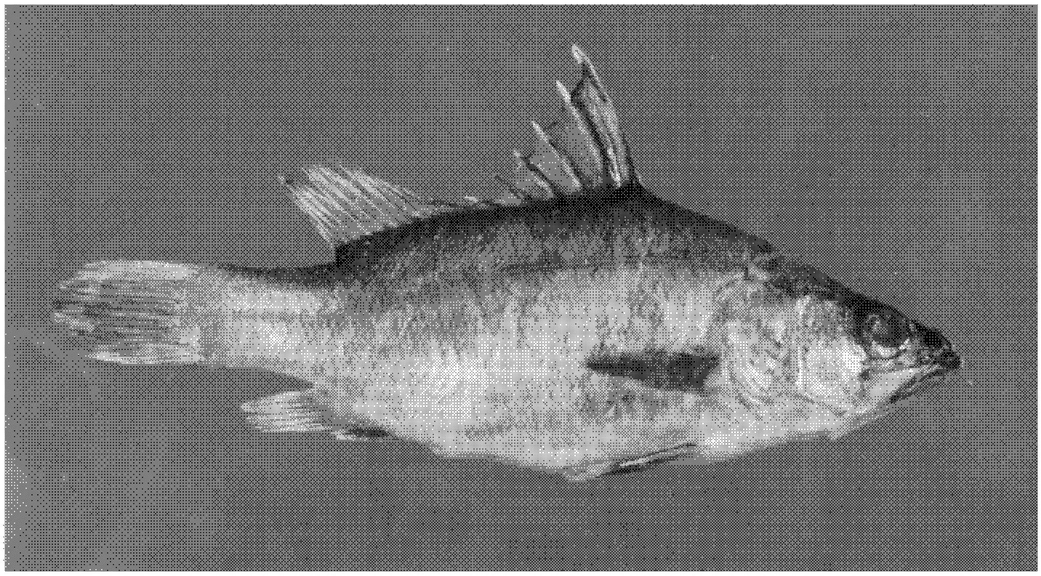


Sarotherodon galilaeus بلطى جليلى

Plate 9.3

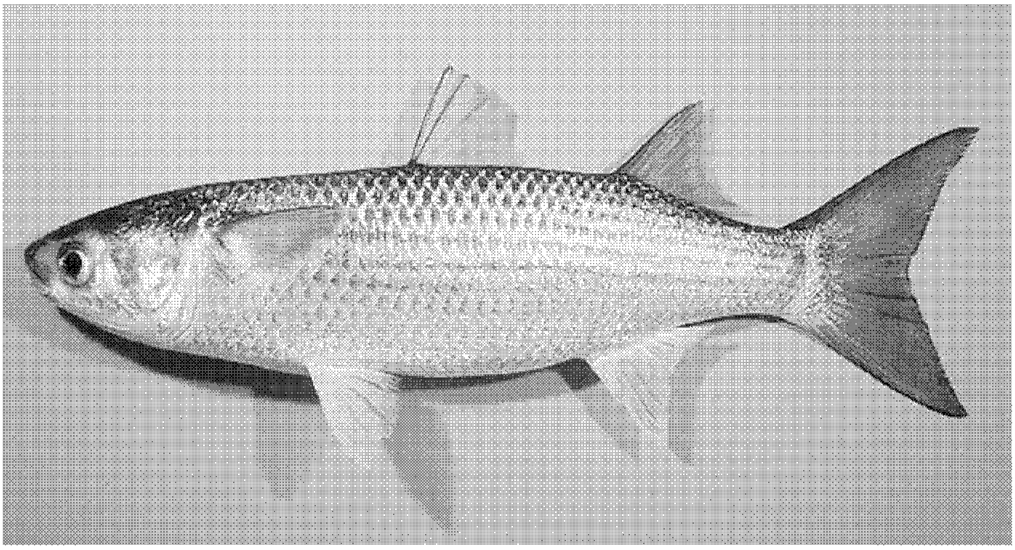


Clarias gariepinus حوت

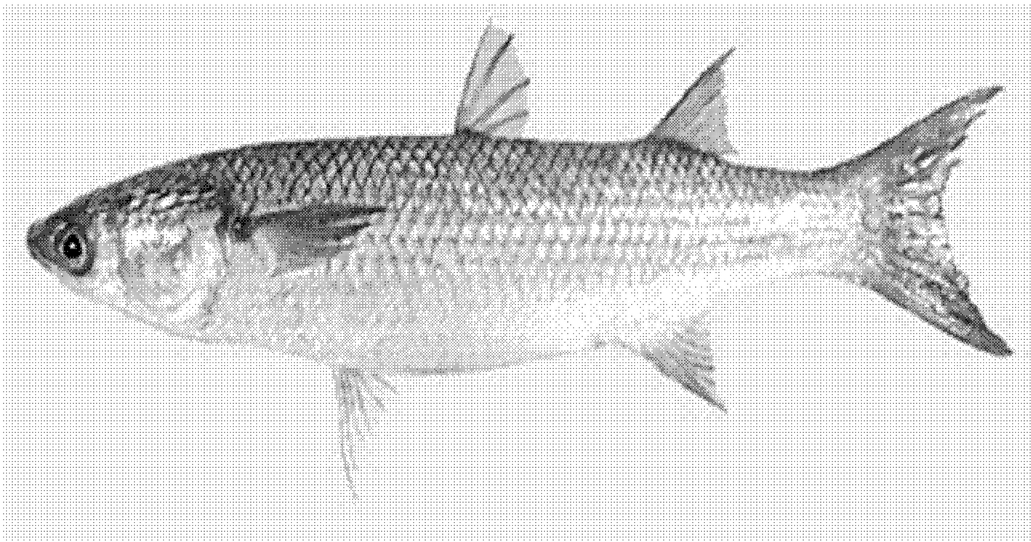


Lates niloticus قشر بياض

Plate 9.4

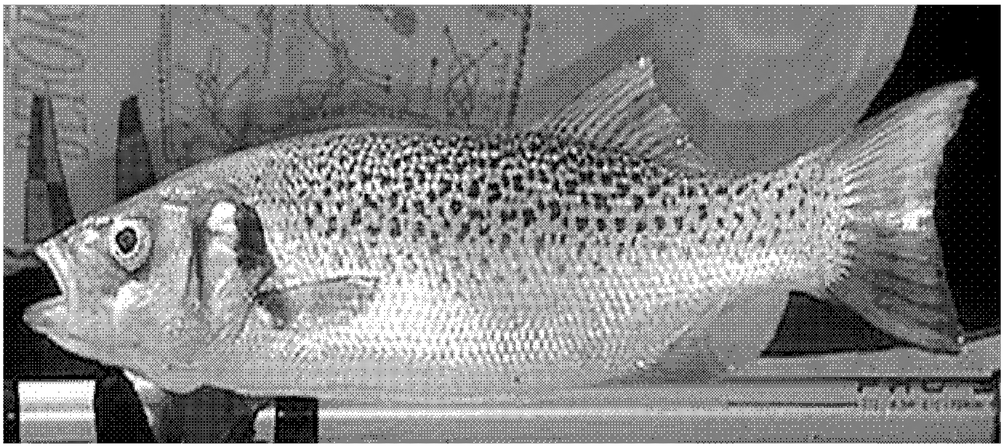


Mugil cephalus بوری

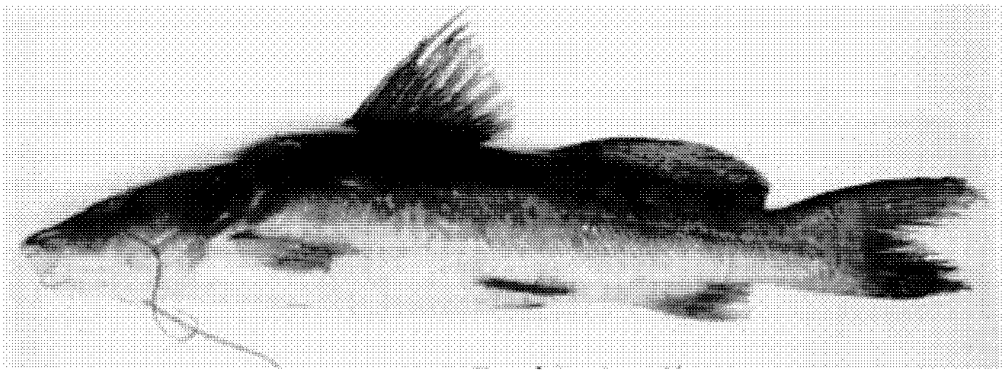


Liza ramada طوبارة

Plate 9.5

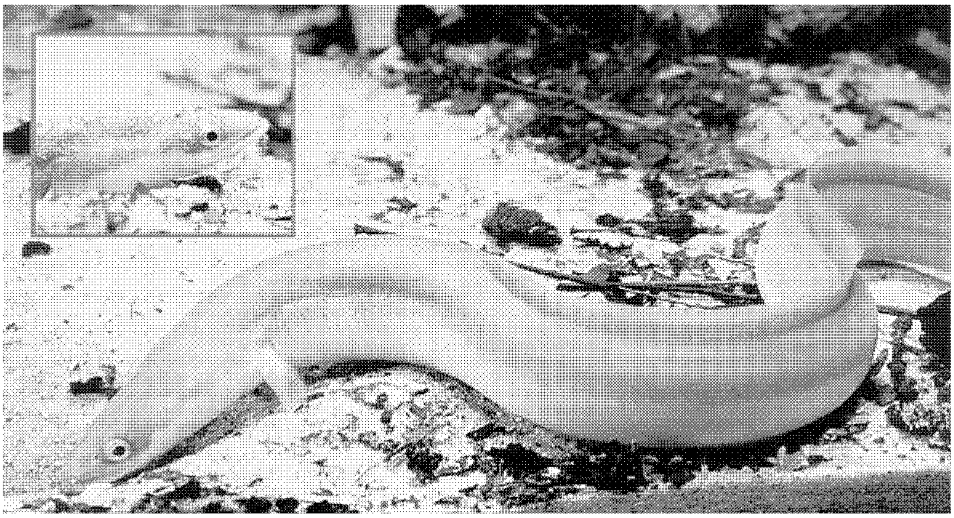


Dicentrarchus punctatus قاروص منقط



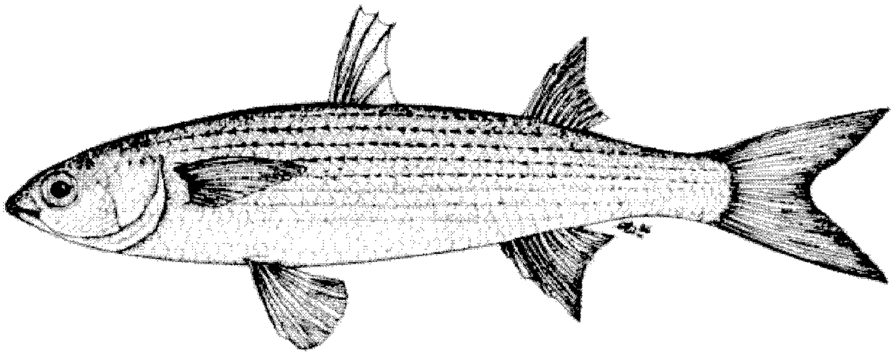
Bagrus bajad بياض

Plate 9.6



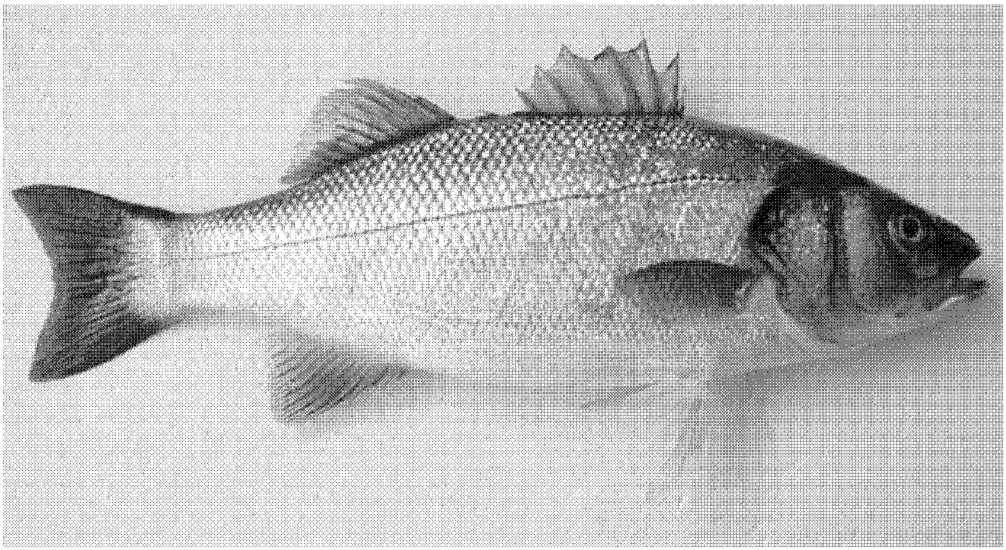
Anguilla anguilla حنش

2 Rare species

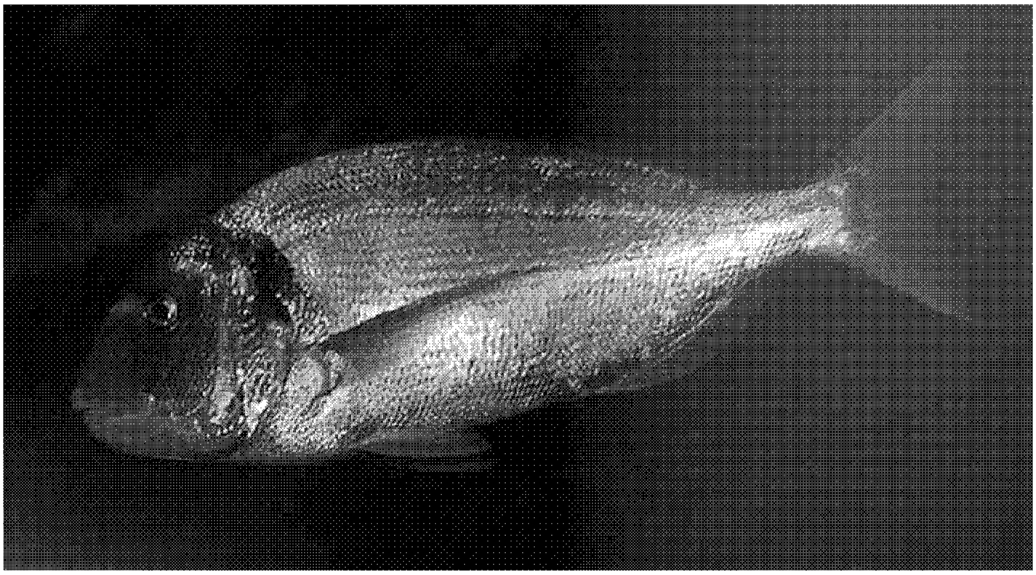


Liza saliens جران

Plate 9.7

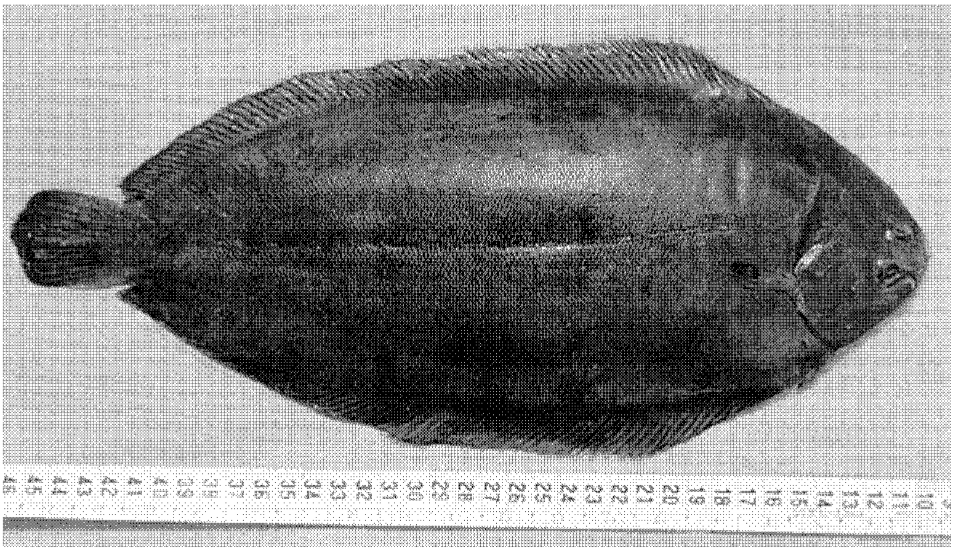


Dicentrarchus labrax قاروص

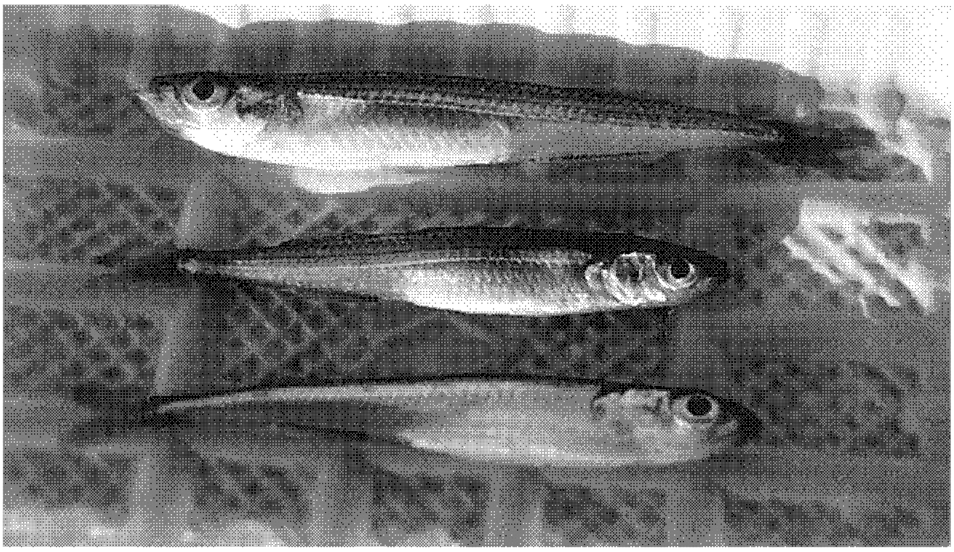


Sparus aurata دنيس

Plate 9.8

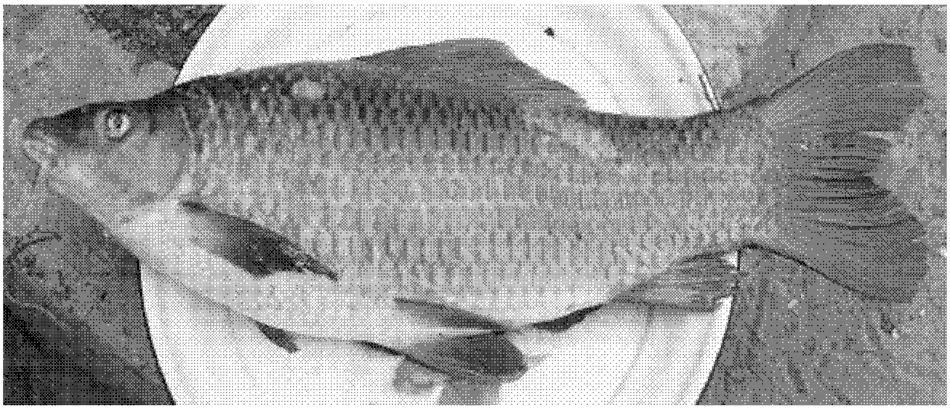


Solea solea موسی



Atherina boyeri بساریا

Plate 9.9


Labeo niloticus لبيس نيلى

3. Very rare species

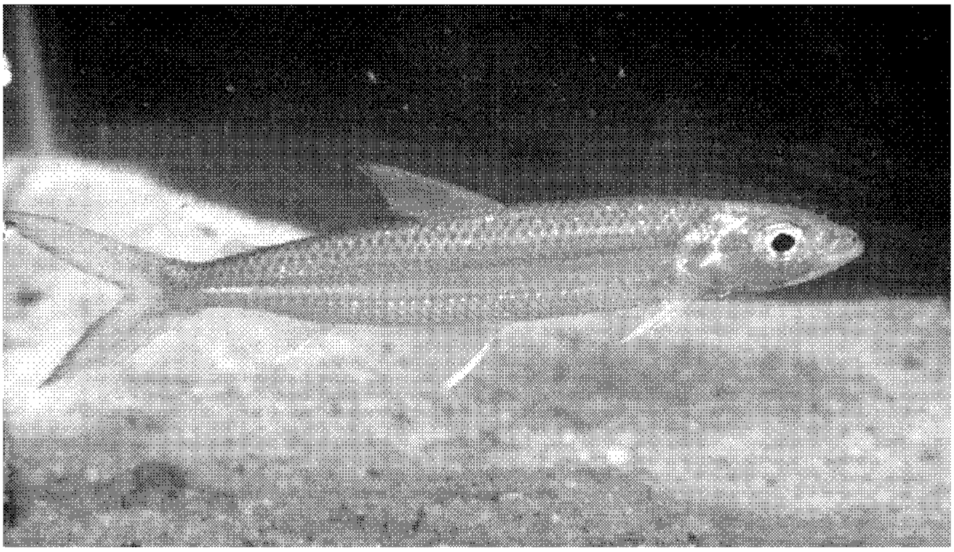
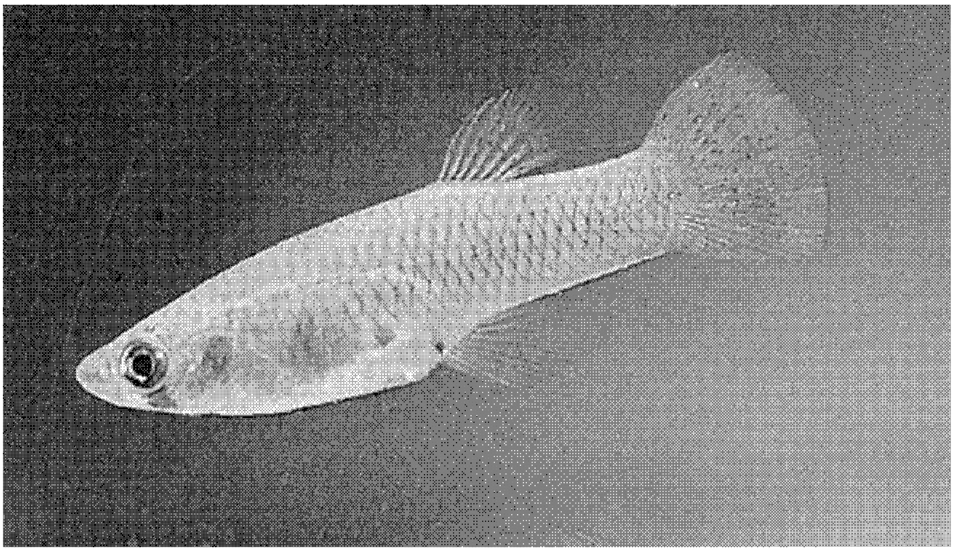
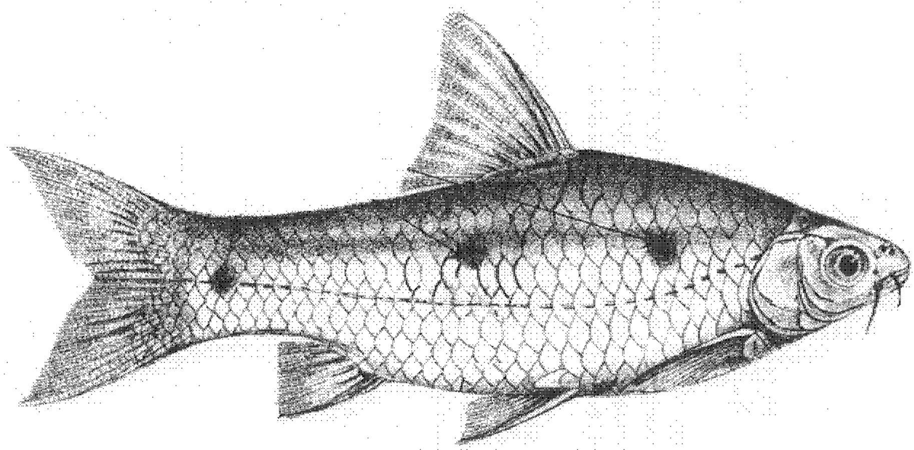

Hydrocynus forskalii كلب السمك

Plate 9.10

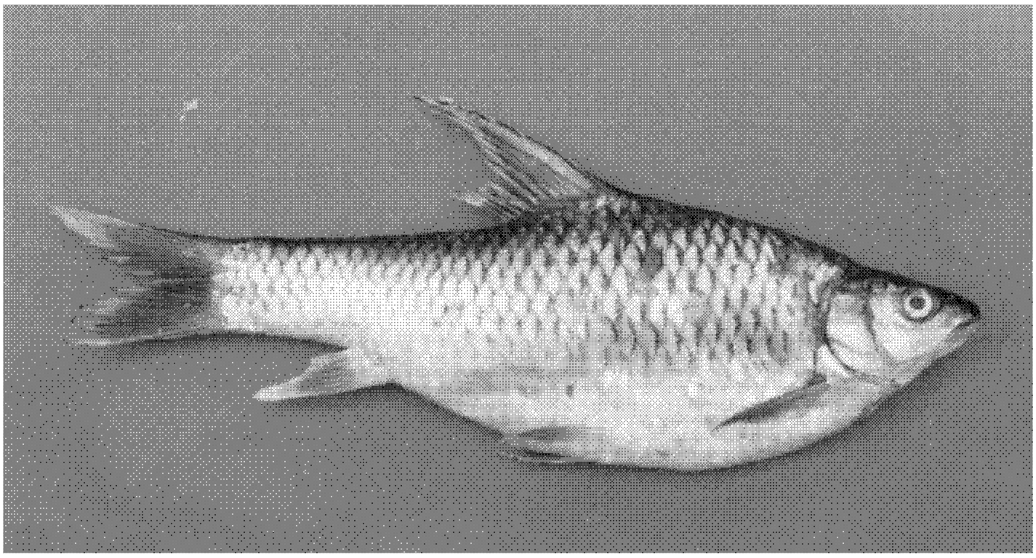


Gambusia affinis جامبوزيا

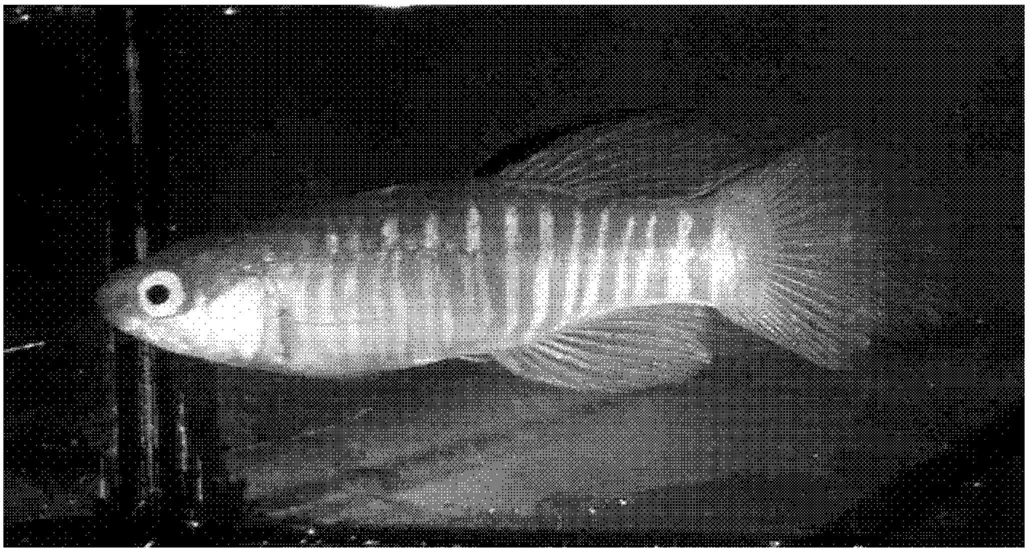


Barbus prince بني برنس

Plate 9.11

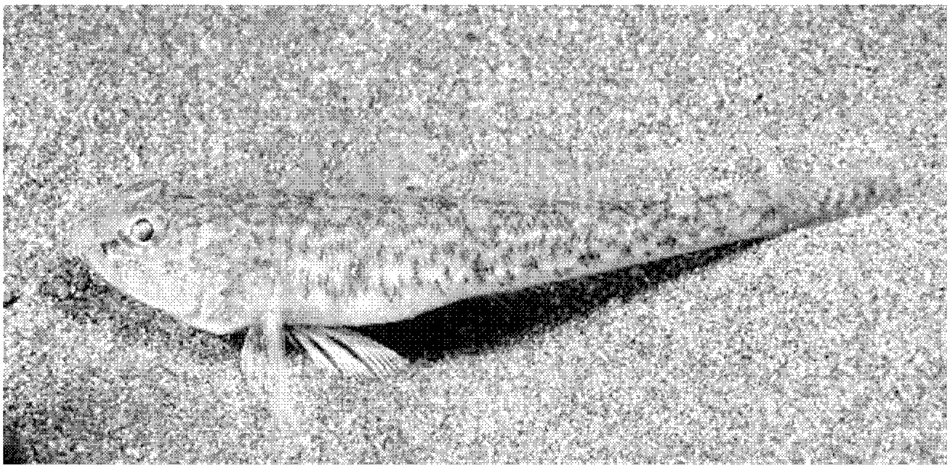


Barbus bynni bynni بنى أصلى

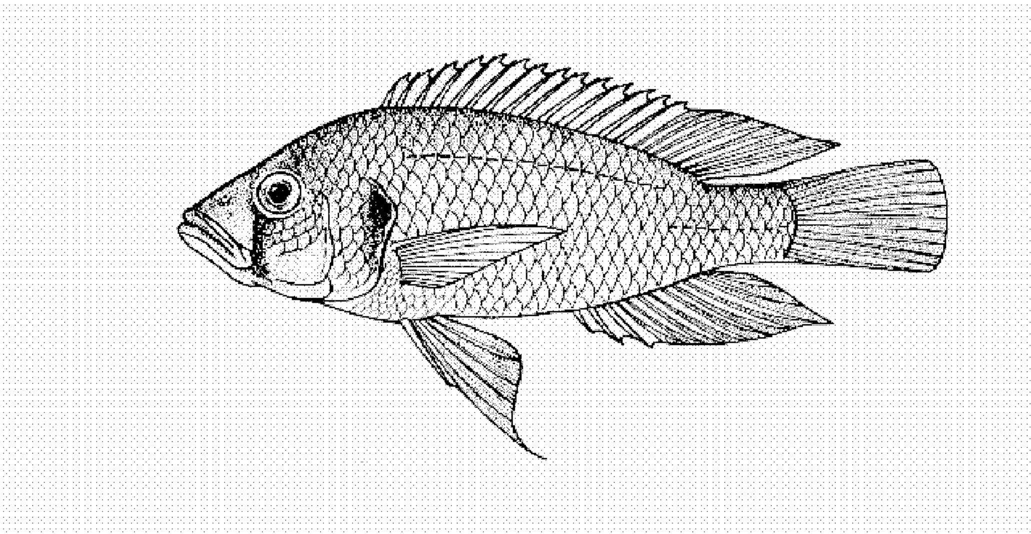


Aphanius fasciatus بطريق

Plate 9.12

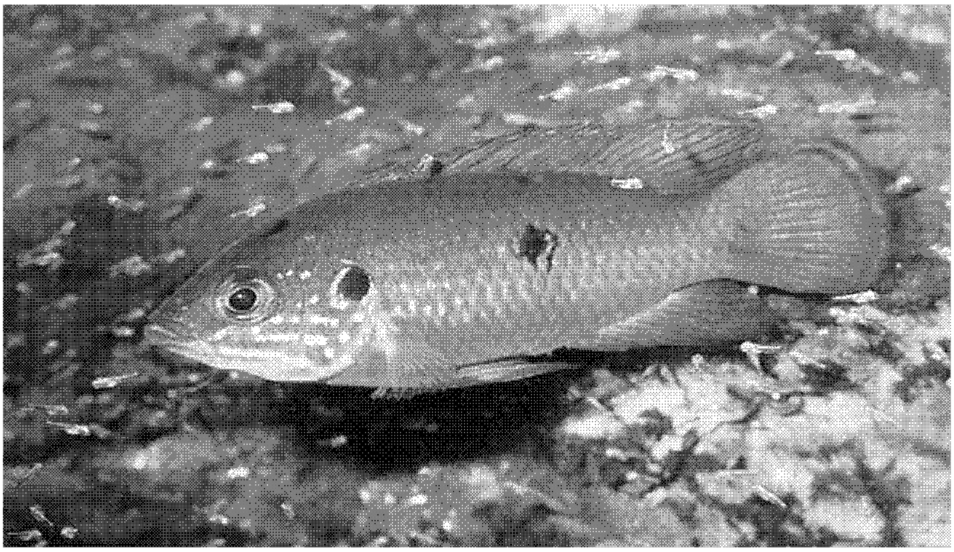


Pomatoschistus microps أبو كرش

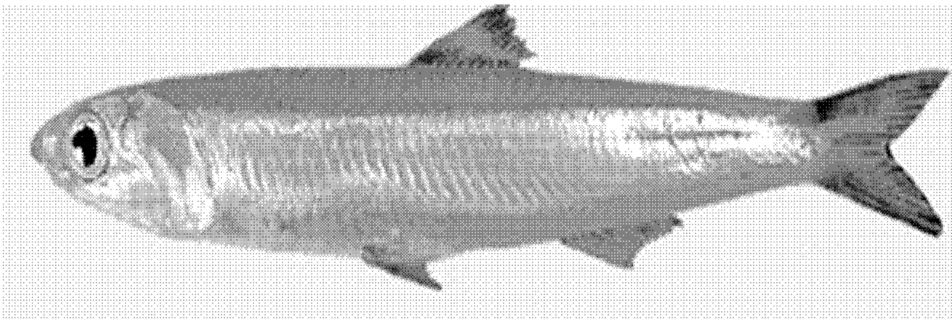


Haplochromis bloyeti هابلوكرومس قزم

Plate 9.13

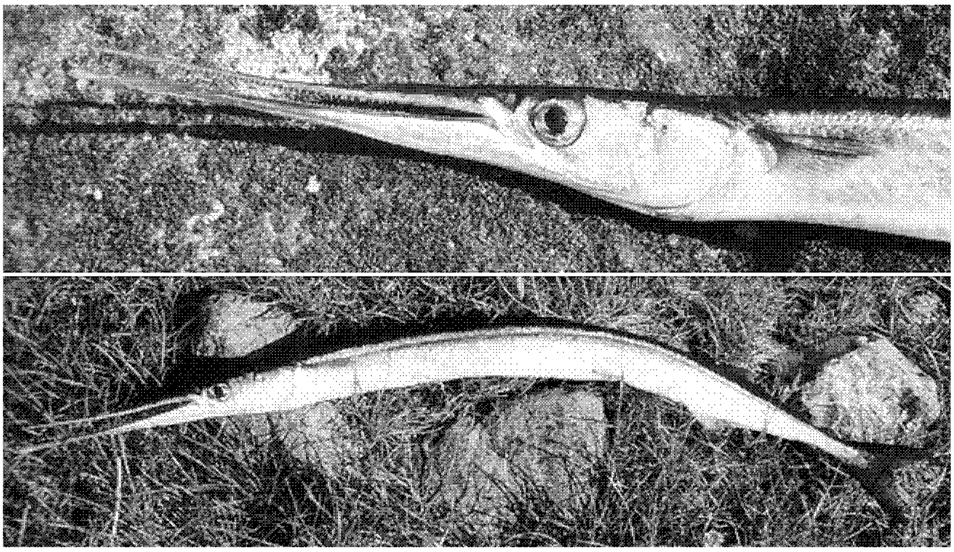


Hemichromis bimaculatus هيمكرومس مخطط

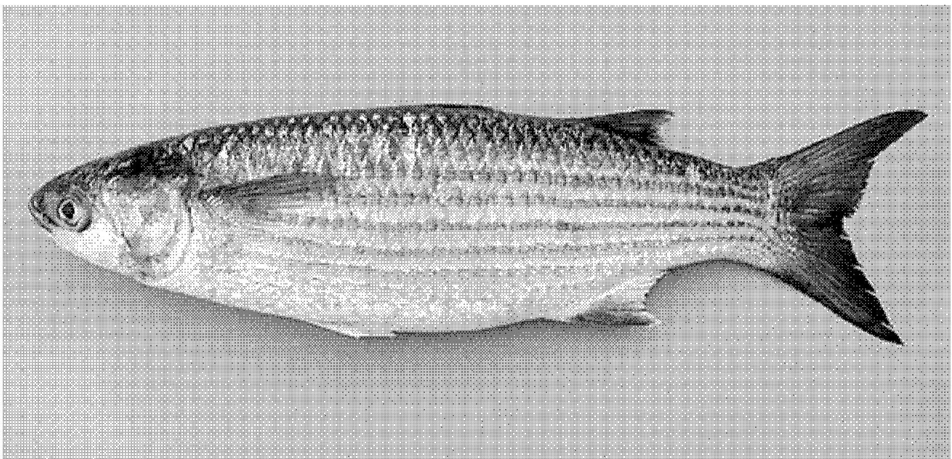


Engraulis encrasicolus انشوجة

Plate 9.14

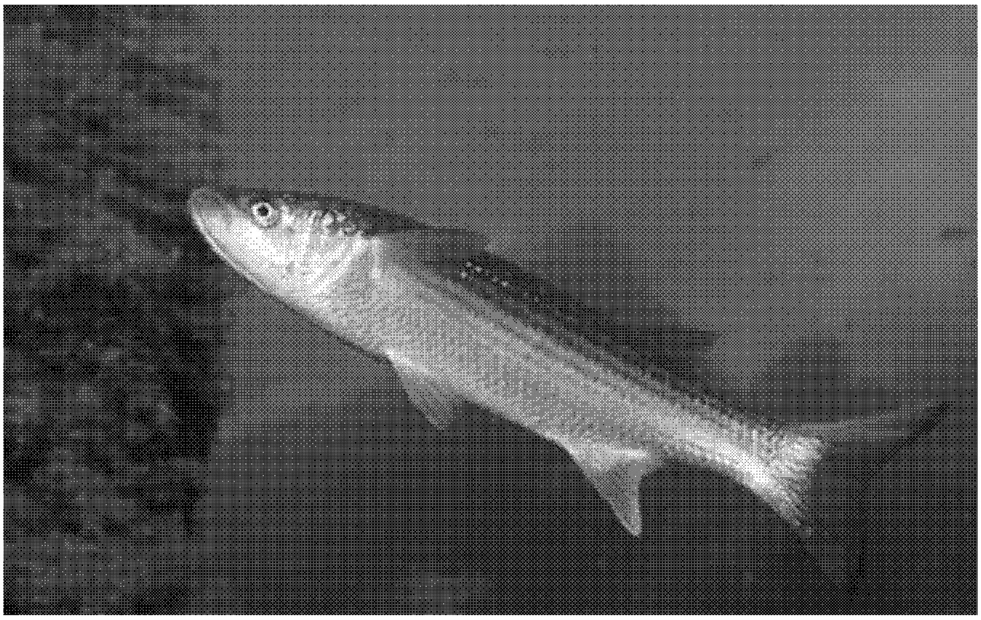


Belone belone خرم

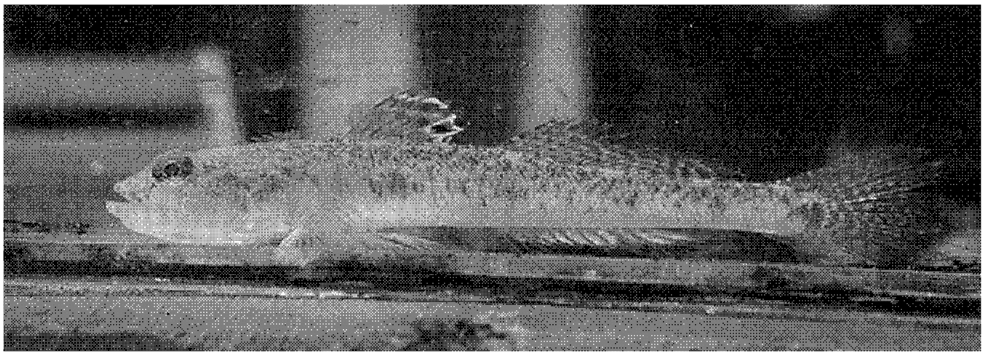


Liza aurata هليلى – دهبانة

Plate 9.15



Chelon labrosus كلونة – بورى سودانى



Pomatoschistus minutus

Chapter 10
Arachnida and Insecta

10.1. ARACHNIDA

Only 23 spiders and scorpions, belonging to 4 orders were recorded in Burullus area during 2000 (El- Hennawy 2000). This survey is considered the first one in Burullus Protectorate, and the species here mentioned are recorded for the first time from this region. El- Hennawy (2000) selected 8 sites as representing different habitats in the Protectorate (Table 10.1, Fig. 10.1) .

***Table 10.1.* The 8 sites of the Archnida study in Burullus Wetland (El-Hennawy 2000).**

Site No.	Location	Latitude (N)	Longitude (E)
1	West Burg El-Burullus	31° 34' 34"	30° 57' 51"
2	West El-Aaqula	31° 31' 39"	30° 49' 00"
3	Near El-Maqsaba	31° 29' 47"	30° 46' 06"
4	Near Mastaroah	31° 28' 55"	30° 41' 15"
5	Near El-Tolombat	31° 30' 51"	31° 03' 51"
6	Near Shabab El-Kharrigeen	31° 26' 14"	30° 30' 31"
7	El-Kawm Al-Akhdar Islet	31° 26' 58"	30° 49' 24"
8	Deshimi Islet	31° 25' 00"	30° 40' 09"

The percentage of collected speciemens of every Arachnida order is indicated in Fig. 10.2. Spiders represent 84% of the total arachnids, followed by scorpions (12%), pseudoscorpions and sun-spiders (2% each).

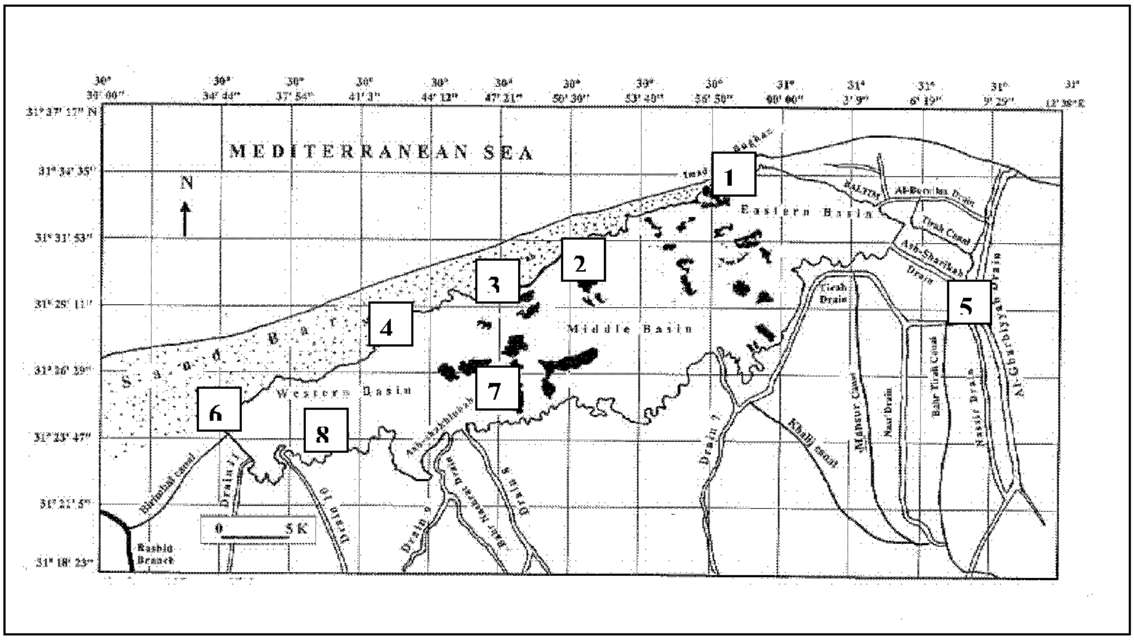


Fig. 10.1. **Map of Lake Burullus showing the sampling sites of Arachnida.**

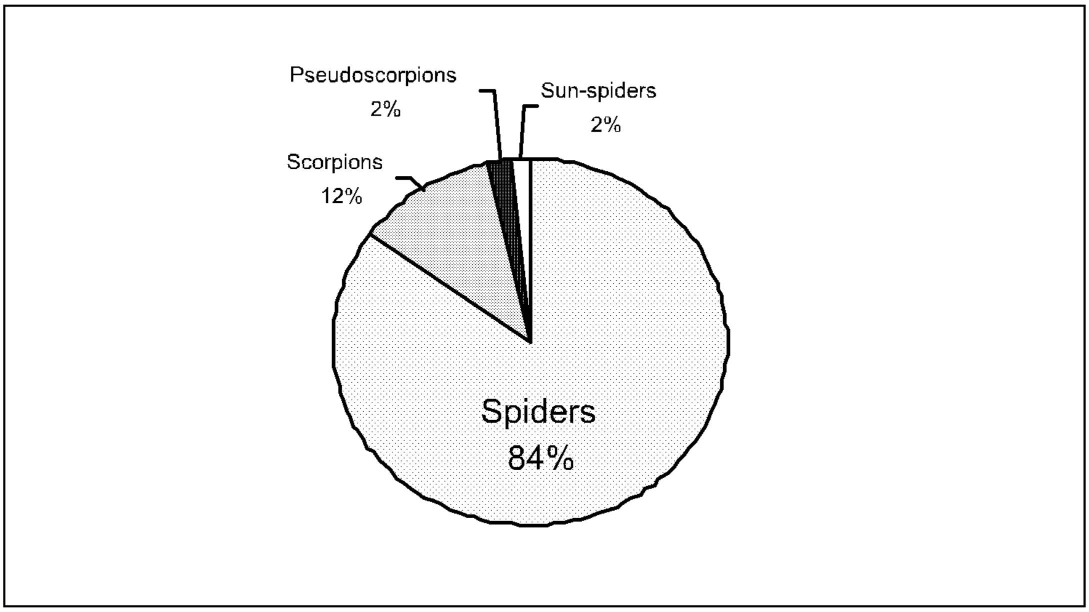


Fig. 10.2. **Percentage of collected specimens of every arachnid order in Burullus Wetland (El-Hennawy 2000)**

10.1.1. Order Araneida (Spiders)

Spiders of 9 families were collected from the eight sampled sites (Fig. 10.3). Both hand collecting and pitfall trapping were used.

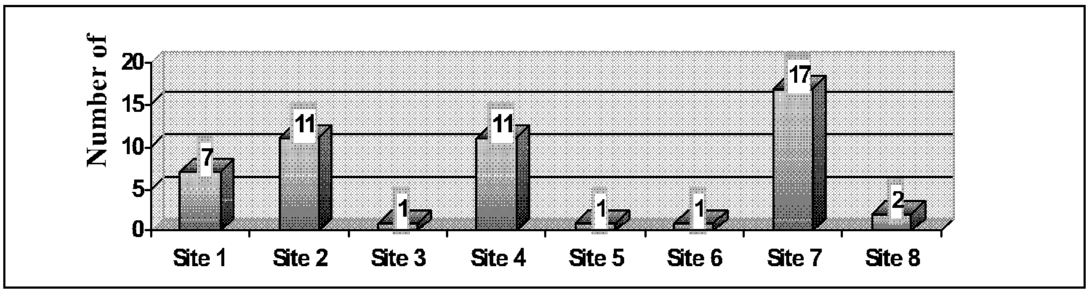


Fig. 10.3. **Number of spider specimens collected for each of the 8 sites in Burullus Wetland.**

10.1.1.1. Family Agelenidae

Two juvenile *Lycosoides* sp. were found under stones in collecting site 7 (Al-Kawm Al-Akhdar Islet). One species of this genus was previously recorded from Alexandria.

10.1.1.2. Family Araneidae

Two females of two different species of genus *Argiope* were found in sites 5 and 6, each in the hub of her orbweb. The first *Argiope trifasciata* had an egg sac attached to the external frame thread of the web among plants. The second *Argiope lobata* was found in the middle of the web in a bare area far from plants in site 6. Also, in site 7, an *Argiope* web with three egg sacs was found but no spider was there. The web and sacs were exacly similar to those of *A. trifasciata*. *A. trifasciata* was recorded from Alexandria, Cairo, Siwa Oasis, Wadi El-Raiyan and Wadi Natron. On the other hand, *A. lobata* was recorded from Alexandria, Cairo, Sinai and Wadi El-Raiyan. In site 4, two other araneid species of two different genera were found among almost dry herbs : two females belong probably to *Agalenatea* (big brown species hides in a retreat attached by threads to the big orbweb) and five subadults and juveniles belong to *Cyclosa* (silvery species always stays in the hub of its small vertical orbweb). One species of *Agalenatea* was recorded from southern Sinai; and another one species of *Cyclosa* was recorded from Siwa and Wadi Natron. In addition, two other unidentified species were collected from sites 5 and 7, the first is a juvenile on a plant attached to the web of *A. trifasciata*, and the second is a female in the hub of her orbweb.

10.1.1.3. Family Clubionidae

Three females of genus *Cheiracanthium* were found in site 7 (Al-Kawm Al-Akhdar Islet) inside deserted nests of the eresid spider *Stegodyphus lineatus*; one female with hatched egg sac of about 40 spiderlings, another one kept alive and laid eggs in captivity to give 24 spiderlings after 11 days. The identification of species of this genus is difficult. The collected species may be an undescribed one. The genus *Cheiracanthium* was transferred to family Miturgidae which may make some confusion with the old literature. Seven species of *Cheiracanthium* were previously recorded from Alexandria, Aswan, Cairo, Siwa Oasis, Wadi El-Raiyan and Wadi Natron. There are many unpublished records of this genus from different regions of Egypt.

10.1.1.4. Family Eresidae

Many nests of *Stegodyphus lineatus* were found on low plants and herbs in site 7. One female was found with egg sac and others alone. There were a nest of spiderlings living together, and many separate nests of young individuals in the vicinity. *S. lineatus* was recorded from Alexandria, Cairo, Damietta, Sinai, Siwa Oasis and Suez.

10.1.1.5. Family Gnaphosidae

The most abundant spider species in the eight collecting sites is that of genus *Pterotricha*. It was found under cement paper bags and carton paper in site 2 and under stones in sites 4 and 8 (Deshimi Islet). It was also collected by pitfall traps in sites 1 and 2. There were adult specimens and juveniles in the same time. Seven species of *Pterotricha* were recorded from Alexandria, Aswan, Cairo, Giza, Siwa Oasis, Suez, Wadi El-Raiyan and Wadi Halfa.

10.1.1.6. Family Lycosidae

Only one unidentified female specimen was collected from site 8 (Deshimi islet) it was running on the ground. Lycosidae were recorded from habitats in several regions of Egypt.

10.1.1.7. Family Philodromidae

Only once, a small and very fast spider of this family (may be of genus *Philodromus*) was observed among plants, but unfortunately it was not able to collect it.

10.1.1.8. Family Salticidae

Only genus *Mogrus* was identified from collected salticid material. Females and juveniles were found in sites 1, 3 and 4. Some females were found with hatched spiderlings inside egg sac on plants. Two species of *Mogrus* were recorded from Alexandria, Siwa Oasis, Upper Egypt, Wadi El-Raiyan and Wadi Natron. Unpublished records were from southern Sinai and Ras El-Barr. A male

and two juveniles of different species were collected in pitfall traps in sites 1 and 2. A distinguished unidentified species was found in site 7 inside deserted nests of *Stegodyphus lineatus* (two of them together and behind the nest of *Cheiracanthium* sp.).

10.1.1.9. Family Theridiidae

Three juvenile specimens of different genera of this family were collected from site 2 under carton paper, and site 7 under stones. Theridiidae were recorded from different regions of Egypt (El-Hennawy 1990 & 1992b)

Comparison between numbers of ground spiders and numbers of insects in two sites (1 and 2) using pitfall traps (10 traps in site 1 and 20 traps in site 2) is indicated in Fig. 10.4. Site 2 (west El-Aaqula) is more rich in insects than site 1 (west Burg El-Burullus), while the reverse is true regarding spiders.

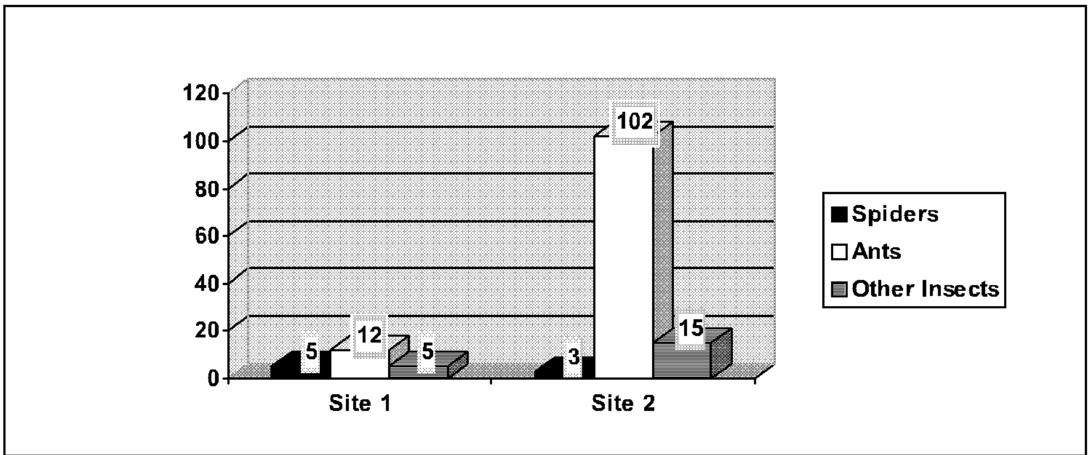


Fig. 10.4. **Comparison between numbers of ground spiders and numbers of insects in two collecting sites (El-Hennawy 2000)**

10.1.2. Order Pseudoscorpionida (False Scorpions)

Only one specimen of family Olpiidae was collected from site 2 (west of El-Aaqula village). It was found under cement paper bag, directly on sand. Olpiidae species were recorded in Egypt from Aswan, Cairo, Giza, Luxor, Senafir Island (Red Sea), Wadi Halfa and Wadi Natron (El-Hennawy 1988).

10.1.3. Order Scorpionida (Scorpions)

Seven specimens of only one species (*Androctonus amoreuxi* of family Buthidae) were collected from site 2 (west of El-Aaqula village). All scorpions were found under cement paper bags and carton paper, sometimes hidden among paper layers. This species is already recorded from many regions in Egypt such as Amarna, Aswan, Auenat, Baharia Oasis, Baltim, Cairo, Edku, Fayum, Helwan, Ismailia, Kafr Amar, Nefiche, Sakkara, Sheik Fadl (Ayat), Siwa Oasis,

Sollum, Suez, SW Bank of Suez Canal, Tamia, Wadi El-Raiyan and Wadi-Halfa (El-Hennawy 1992a). Baltim is one of the previous locations of this species; it lies within the Burullus Protectorate.

10.1.4. Order Solpugida (Sun Spiders, Camel Spiders, Wind Scorpions)

Only one juvenile specimen of family Daesiidae was collected from site 7 (Al-Kawm Al-Akhdar Islet). It was found under a stone among plants. Daesiidae species were recorded in Egypt from Abu Galoum Protectorate, Alexandria, Aswan, Bir Abraq, Bir El-Gahliya, Cairo, El-Fayum, El-Shalateen, Luxor, Nabq Protectorate, Ras Mohammed Protectorate, Saint Catherine, Upper Egypt, Wadi Digla, Wadi Feiran, Wadi Ramad and Wadi Sarmatai (El-Hennawy 1998).

El- Hennawy (2000) concluded that the dominant families of spiders in Burullus area were: Gnaphosidae, Salticidae and Araneidae. Spider families Agelenidae, Clubionidae, Eresidae and the single specimen of order Solpugida were only represented in site 7 (Al-Kawm Al-Akhdar Islet). Only one scorpion species *Androctonus amoreuxi* and the single specimen of order Pseudoscorpionida were collected from site 2 (west of El-Aaqula village). Therefore, sites 1, 2 and 4 of the marine bar and site 7 (Al-Kawm Al-Akhdar islet) are the best sites to be more studied. They are appropriate for ecological monitoring programs. A whole survey to know what species are living in the above mentioned sites, and in the Protectorate as a whole is the first and the most important step to be done before any ecological study in the area.

10.2. INSECTA

Metwally (2000) studied the insect community in Burullus Protected Area from mid July to mid September 2000 through the MedWetCoast Project. He conducted his investigation at the following eleven sites in Burullus Wetland: El- Makata, El-Kodia, Batn El-Koum, El- Maktoua, Ebsak, El-Koume, El-Dakhla, El- Zanka, Arada, Frash El-Toup, and Dechimi. Also, he took into consideration the lake shores as well as the insects located above and beneath the water surface of the Lake. 95 species belonging to 59 families and 16 orders were identified in his survey (Table 10.2). The most numerous species were: *Aphis* sp., *Bemisia labaci*, *Musca* sp., *Chironomus* sp., *Culex pipiens, Monomoriun pharaonsis, Componotus maculates, Cataglyphus bicolor* and *Sesamia wiltshieri*. No doubt, that these data underestimate the insect fauna of the region due to the short period of this study (only 2 months). So, Metwally recommended the urgent need to carry out an intensive and extensive study, based on monthly intervals, for a period of at least two continuous years, to get a real picture about the insect diversity of this region.

Table 10.2. **Insect species in Burullus Protected Area. I = Islets, S = Lake shores, W = Lake water, N = Numerous (after Metwally 2000).**

Order	Family	Species	Habitat	Rough number
Odanatas (Damsel and Dragon flies)	**Aeschnidae**	***Hemianax ephippiger***	**I+S**	**30**
		***Anax* sp.**	**I+S**	**2**
		***Aeshna* sp.**	**I+S**	**2**
	Cordullidae	***Maromia* sp.**	**I+S**	**2**
	Libellulidae	***Libellula puplchella***	**I+S**	**4**
		L. plathemis	**I+S**	**3**
		Orthectrum chrysostigma	**I+S**	**8**
		Crocothemis erythraea	**I+S**	**20**
	Coenagriidae	***Ischnura senegalensis***	**I+S**	**30**
Thysanoptera (Thrips)	**Phlaeothripidae**	***Haplothrips cottei***	**S**	**4**
	Thripidae	***Limothrips cerealium***	**S**	**5**
Plecoptera (Stoneflies)	**Isoperlidae**	***Perla maxima***	**I+S**	**6**
		Isoperla confusa	**S**	**2**
Ephemeroptera (Mayflies)	**Polymitarcidae**	***Polymitarcys savignii***	**I+S**	**5**
Collembola (Springtails)	**Poduridae**	***Lepidocyrtinus insertus***	**I+S**	**20**
	Sphearidae	***Sphearida* sp.**	**I+S**	**10**
	Onychiuridae	***Onychiurus* sp.**	**I+S**	**5**
	Tulbergidae	***Tulbergi* sp.**	**I+S**	**10**
	Folsomidae	***Folsomides* sp.**	**I+S**	**8**
	Freiseoidae	***Freisea* sp.**	**I+S**	**6**
	Hypogastruidae	***Hypogasterura* sp.**	**I+S**	**7**
	Isotomidae	***Isotomodes* sp.**	**I+S**	**2**
	Entombyridae	***Entombyra* sp.**	**I+S**	**4**
Hemiptera	**Pentatomidae**	***Nezara viridula***	**I+S**	**50**
	Anthocoridae	***Orius* sp.**	**S**	**15**
	Belostomatidae	***Lethocerus niloticus***	**W**	**2**
		Bencus griseus	**W**	**1**
		Bencus griseus	**W**	**2**
		Sphaerodema Urinator	**W**	**2**
		Limnogeton fieberi	**W**	**2**
	Nepidae	***Ranatra vicina***	**W**	**1**
	Notornectidae	***Notonecta* sp.**	**W**	**2**
	Corixidae	***Sigara selecta***	**W**	**2**
Homoptera Aphidiae	**Aphididae**	***Aphis* sp.**	**S**	**N**
	Aleyrodidae	***Bemisia labaci***	**I+S**	**N**
	Cicadellidae	***Empoasca* sp.**	**I+S**	**10**
Neuroptera (Lacewigs)	**Myrmeliontidae**	***Cueta* sp.**	**S**	**2**
	Chrysopidae	***Chrysoperla* sp.**	**S**	**6**

Table 10.2. Cont. 1.

Order	Family	Species	Habitat	Rough number
Dermaptera (Earwigs)	**Labiduridae**	***Labidura riparia***	I+S	5
		Euborellia annulipes	I+S	2
	Forficulidae	***Diaperasticus erythocephalus***	I+S	2
Orthoplera	**Tettigoniidae**	***Conocephalus mondibularis***	I+S	20
	Gryllidae	***Liogryllus bimaculatus***	S	10
		Gryllus domestica	S	3
	Acrididae	***Locusta migratoria***	I+S	3
		Anacridium aegyptium	I+S	4
		Euprpocnemis plorans	I+S	20
		Thisoicetrus littoralis	I+S	25
		Aiolopus strepens	I+S	20
		Acrotylus insubricus	I+S	10
	Gryllotalpidae	***Gryllotalpa gryllotalpa***	S	4
		G.gryllotalpa var. Cophta	S	2
		G. africana	S	3
Trichoptera	**Polycentropidae**	***Dipseudopsis* sp.**	S	2
Montodea	**Mantidae**	***Sphodromantis bioculata***	I+S	10
		Mantis religiosa	I+S	5
		Calidomantis sarignyi	I+S	4
Diptera	**Muscidae**	***Musca* sp.**	I+S	N
		Stomoxys calcitrans	I+S	10
	Tabanidae	***Tabanus* sp.**	I+S	6
	Chironomidae	***Chironomus* sp.**	I+S	N
	Culicidae	***Culex pipiens***	I+S	N
		***Anopheles* sp.**	I+S	15
		***Aedes* sp.**	I+S	10
	Ephedridae	***Ephydra riparia***	I+S	12
	Tachinidae	***Tachina* sp.**	S	10
	Sarcophagidae	***Sarcophaga* sp.**	I+S	20
	Syrphidae	***Syrphus* sp.**	I+S	6
	Calliphoridae	***Lucilia sericata***	S	3
		Calliphora erythrocephala	S	1
Hymenoptera	**Formicidae**	***Monomorium pharaonsis***	I+S	N
		Camponotus maculatus	I+S	N
		Cataglyphus bicolor	I+S	N
	Vespidae	***Vespa orientalis***	S	2
		Polistes gallica	S	3
Coleoptera	**Dytiscidae**	***Cybister tripunctatus***	W	20
	Carabidae	***Calosoma* sp.**	S	3
	Scarabaeidae	***Pentodon* sp.**	S	10
	Dermestidae	***Dermestes* sp.**	I	20
	Staphylinidae	***Paederus alfierii***	I+S	17

Table 10.2. Cont. 2.

Order	Family	Species	Habitat	Rough number
	Coccinellidae	*Coccinella undecimpuncata*	I+S	50
		Coccinella septumpunctata	S	4
		Scymnus sp.	S	40
		Cydania vicina nilotica	S	40
		C. vicina isis	S	1
	Hydrophilidae	*Rhanatus* sp.	W	2
Lepidoptera	Nymphalidae	*Vanesa* spp.	S	5
	Pieridae	*Pieris rapae*	S	6
	Hesperiidae	*Pelopidas thrax*	I+S	50
		Pelopidas borbanica	I+S	100
		Gegenus nostrodames	S	5
	Pyralidae	*Chilo* sp.	I+S	100
	Agrotidae	*Diatraea saccharalis*	S	4
		Sesamia wiltshieri	I+S	N
		Agrotis sp.	S	2
Total : 16 orders	59 Families	95 species		

Metwally (2000) divided the recorded insects of Burullus Protected Area into three groups according to their habitats as follows: terrestrial (islets), semi-aquatic (lake shores) and aquatic (lake water) insects. The majority of these species inhabit the islets and shores in the same time (55 species = 57.9 %) and the shores only (29 species = 30.5 %). On the other hand, only 10 species were recorded in the water zone (Fig. 10.5). He mentioned that different species of weeds, reeds and shrubs of Burullus area represent good plant hosts for the insects around the year, as well as suitable sites for many beneficial and harmful insects (predators and parasites). He concluded also that Lake Burullus was considered as an important source of harmful insects which can be transmitted from the lake to the adjacent lands cultivated with important economic plants.

10.3. SUMMARY

Only 23 spiders and scorpions, belonging to 4 orders were recorded in Burullus Wetland during a short period study. Twenty spider species (Order Araneida), representing 9 families were recorded. Only one specimen of false scorpions (Order Pseudoscorpionida) belongs to family Olpiidae was collected. In addition, seven specimens of one species of scorpions (Order Scorpionida) *Androctonus amoreuxi* (family Buthidae) were collected, and also only one specimen of camel spiders (Order Solpugida) belongs to family Daesiidae was collected from Al-Kawm Al-Akhdar Islet.

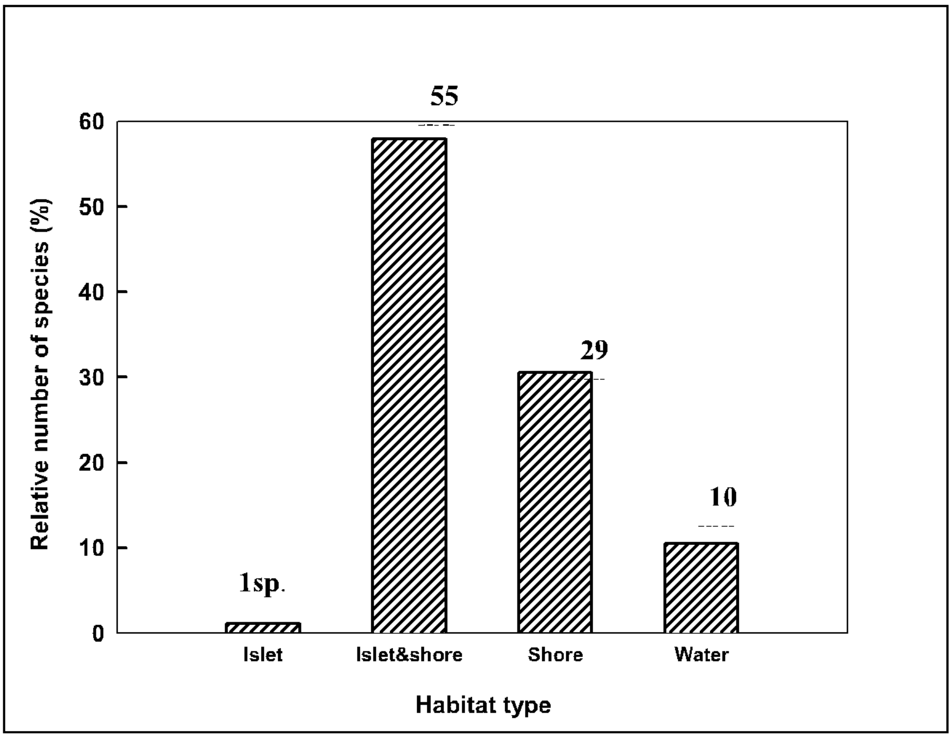


Fig. 10.5. **Number of insect species in relation to habitat type in Burullus Wetland.**

On the other hand, 95 insect species belonging to 59 families and 16 orders were identified. No doubt, these data underestimate the insect fauna of the region due to the short period of this study (only 2 months). So, it is recommended to carry out an intensive and extensive study, based on monthly intervals, for a period of at least two continuous years, to get a real picture about the insect diversity of this region

10.4. REFERENCES

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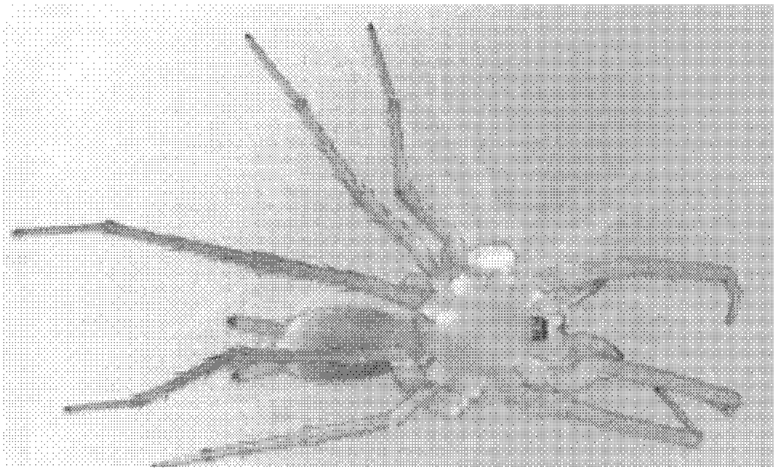
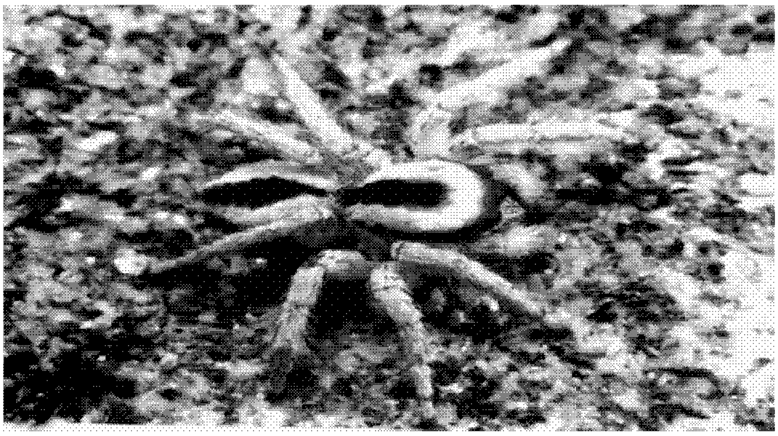
10.5. PLATES OF ARACHNIDA
(after El-Hennawy 2000)

Plate 10.1
Pterotricha sp.
Mogrus sp.
Androctnus amoreuxi

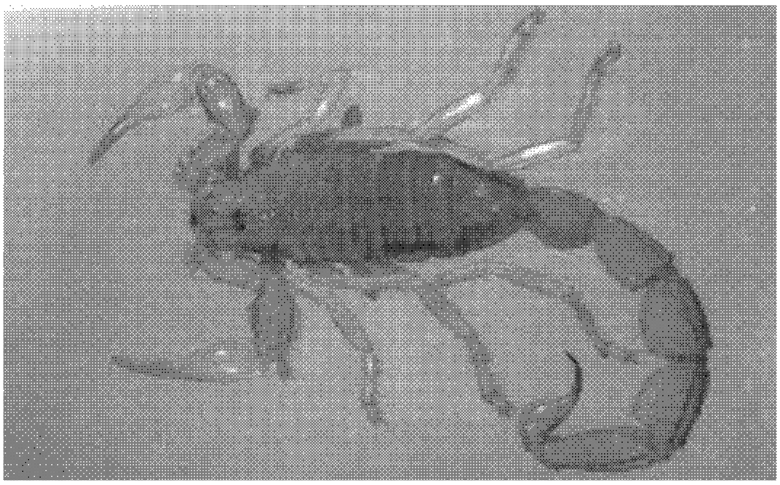
Plate 10.1



Pterotricha sp.(♀)



Mogrus sp.(♂)



Androctnus amoreuxi

Chapter 11
Herpetofauna

Twenty three species of reptiles and amphibians have been reported from Burullus Protected Area (Table 11.1), consisting of nine lizards, six snakes, two marine turtles and five amphibians (Anonymous 2002; Saber 2003). The herpetofauna is abundant and moderately diverse. The number of amphibian species (and their relative abundance) is notably high (five out of eight Egyptian amphibians), reflecting the availability of freshwater wetland habitats. The most common species are Bosc's Fringe-Toed Lizard *Acanthodactylus boskianus*, Egyptian Toad *Bufo regularis* and Mascarene Frog *Ptychadena mascareniensis*.

11.1. ENDEMIC SPECIES

The recently described Nile Valley Toad *Bufo kassasii* is an Egyptian endemic, found in localized, but dense populations in suitable freshwater swamps along the southern margins of the Protected Area. The species is thus far only known from the Nile Valley in Egypt. It is not under any immediate threat, and is expanding its range in Egypt.

11.2. RARE SPECIES

Four species are characterized as rare. The isolated population of Audouin's Skink *Sphenops sepsoides* is particularly interesting from a biogeographic point of view. The species is a widespread Saharan inhabitant of sandy biotopes common elsewhere in Egypt. This population is under threat as a result of habitat loss. The relict population of Javelin Sand Boa *Eryx jaculus* inhabiting Burullus Protected Area is under a similar threat, compounded by intense collection pressure from animal traders, because of its desirability in the pet trade.

Table 11.1. **Reptiles and amphibians recorded from Burullus Protected Area**

Latin name	English name	Arabic name	Abundance
Acanthodactylus boskianus	Bosc's Fringe-toed Lizard	سقنقر خشن	Common
Acanthodactylus scutellatus	Nidua Fringe-toed Lizard	سقنقر الرمل الكبير	Uncommon
Acanthodactylus schreiberi			
Bufo kassasii	Nile Valley Toad	ضفدع قصاص	Uncommon
Bufo regularis	Egyptian Toad	ضفدع نيلي	Abundant
Bufo viridis	Green Toad	ضفدع أخضر	Uncommon
Caretta caretta	Loggerhead Turtle	ترسة	Rare
Chalcides ocellatus	Ocellated Skink	سحلية دفانة	Common
Chamaeleo africanus	African Chameleon	حرباء أفريقيا	Uncommon
Chamaeleo chamaeleon	Common Chameleon	حرباء	Uncommon
Chelonia mydas	Green Turtle	سلحفاة بحرية خضراء	Rare
Coluber florulentus	Flowered Snake	أزرود	Uncommon
Eryx jaculus	Javelin Sand Boa	دساس بلدى	Rare
Hemidactylus turcicus	Turkish Gecko	برص منزلي	Common
Mabuya quinquetaeniata	Bean Skink	سحلية جراية	Common
Mabuya vittata	Bridled Skink	سحلية جراية مخططة	Uncommon
Malpolon monspessulana	Montpelier's Snake	ثعبان خضارى	Common
Naja haje	Egyptian Cobra	كوبرا مصرى	Uncommon
Natrix tessellata	Diced Water Snake	ثعبان الماء	Uncommon
Psammophis sibilans	African Beauty Snake	ابو السيور	Uncommon
Ptychadena mascareniensis	Mascarene Frog	جزاع ابو خطين	Common
Rana ridibunda	Lake Frog	جزاع أخضر	Common
Sphenops sepsoides	Audouin's Skink	سحلية نعامة	Rare

11.3. NOTEWORTHY SPECIES

Javelin Sand Boa *Eryx jaculus*, African Chameleon *Chamaeleo africanus*, Common Chameleon *Chamaeleo chamaeleon* and Montpelier's Snake *Malpolon monspessulanus* are heavily collected by animal collectors for pet trade. It is doubtless that some of the animals available on the market originate from the Protected Area. Several tons of the Lake Frog *Rana ridibunda* are exported from Egypt each year (as a food item). The origin of these animals is not known, but it is likely that many could come from the Burullus region. The Egyptian Cobra *Naja haje* is the only fully venomous snake recorded in the Protected Area. It is dangerous to man, however cases of invenomation seem to be rare. Hundreds of these snakes are collected for serum production every year.

11.4. THREATENED SPECIES

There are five globally threatened reptile species occurring in Egypt according to the IUCN Red List of Threatened Animals (IUCN 2000). Two of which have been recorded in Burullus Protected Area: Loggerhead Turtle *Caretta caretta* (Endangered) and Green turtle *Chelonia mydas* (Endangered).

The Javelin Sand Boa *Eryx jaculus* is the most threatened species at the local level.

In addition to the mentioned threatened species, Saber (2003) mentioned that some other species need special management, such as *Mabuya vittata*, which is the most characteristic species to the study area and has narrow geographic range in Egypt. In spite of the wide range of geographic distribution of *Sphenops sepsoides* in Egypt, Saber (2003) record is the only one of the whole Delta. *Malpolon monspessulanus insignita* is threatened by a severe collection for commercial exploitation, which may affect the population of this species if it is not stopped. *Acanthodactylus schreiberi*, 1878 has been added for the first time to the herpetofauna of Egypt and more efforts should be done to explore its distribution and ecology.

11.5. MAJOR THREATS

1- Commercial exploitation is the most significant threat facing herpetofauna in the area, which affects practically all species. This activity has reached a considerable level in recent years and is posing a real threat upon the survival of several species.

2- Habitat destruction is another factor that appears to be affecting some of the reptiles and amphibians of the area. Agriculture land reclamation as well as widespread urbanization has transformed natural habitats into agricultural fields or urban centres not suitable for their original amphibians and reptilian inhabitants. Coastal habitats are being destroyed by major urban projects, road construction and beachfront lighting often prevent hatchlings of sea turtles from successfully departing their natal beach, or adults from emerging to nest. Over-grazing and over-crowding of cows on the islets severely affect the reptile fauna on these islets. Habitat destruction in the area must have contributed to the great decline in the population of the endangered species especially the critically endangered sea turtles.

3- Environmental pollution, particularly that caused by pesticides, is probably affecting aquatic or semi-aquatic forms; solid wastes which can be a danger, such as plastic bags in the sea which kill sea turtles that ingest them.

4- Introduced species such as feral cats and dogs, which affect the population of amphibians and reptiles by predation. Grazing domestic animals may cause overgrazing to the habitat. One of the threats of the herpetofauna is the human because many species of amphibians and reptiles have a very negative image in the mind of the general public.

11.6. SPECIES ACCOUNT

Class: Amphibia

Order: Anura

Family: Bufonidae

***1- Bufo regularis regularis* Reuss, 1834**

Common name: Egyptian Toad; ضفدع نيلى

World distribution: Europe, all of Africa except the northwest and Tibet.

National distribution: Nile Valley and Delta, El-Faiyum and the newly reclaimed areas of the Mediterranean coastal desert of Alexandria.

Burullus observation sites: Burg El-Burullus and near El-Tolombat

Habitat: Dry or moist biotopes.

Ecology: Nocturnal except during the mating period. It is typically freshwater species; it feeds on insects, worms and snails. It is considered one of the most effective insect predators in cultivated areas in Egypt.

Status: Lower Risk (Least concern).

***2- Bufo viridis viridis* Laurenti, 1768**

Common name: Green Toad; ضفدع أخضر

Range: Europe, North Africa, westward to Mongolia and Tibet.

National distribution: Nile Valley and Delta, western desert oases, El Faiyum, Mediterranean coastal Desert and Suez Canal area.

Ecology: Found in both fresh and brackish water habitats.

Status : Low Risk (least concern).

***3- Bufo kassasii* Baha el Din, 1993**

Common name : Kassas's Toad; ضفدع قصاص

World distribution: Known only from Nile Delta, Egypt.

National distribution: Nile Delta.

Ecology: A highly aquatic toad inhabiting marshy area, Nile banks with dense floating vegetation and flooded rice fields.

Status: Data deficient, but apparently common at suitable habitats.

Family: Ranidae

***4- Ptycadena mascareniensis* (Dumeril and Bibron, 1841).**

Common name: Mascareniensis Frog; جزاع ابو خطين

World distribution: Africa.

National distribution: Nile Valley and Delta and reclaimed desert areas irrigated by Nile water.

Burullus observation sites: Near El-Tolombat

Habitat: Irrigation and drainage canals with dense waterside vegetation, rice fields and other fresh water habitat. Flower (1933) found this frog in the brackish shallow water at the edge of Lake Manzala.
Ecology: Nocturnal and crepuscular. It feeds on insects and small invertebrates. It is considered one of the most effective insect predators in cultivated areas in Egypt.
Status: Lower Risk (Least concern).

Family: Ranidae

***5- Rana ridibunda* Pallas, 1771.**
Common name: Lake frog; جزاع اخضر
World distribution: North Africa, central and southern Europe to west Asia.
National distribution: Lower Nile Valley and Mediterranean coastal area in northeastern Sinai.
Burullus observation sites: Al-Kawm Al-Akhdar and Deshimi Islets.
Habitat: Freshwater ponds and canals. It was found in brackish marshes with dense emergent vegetation in Al-Kawm Al-Akhdar and Deshimi islets in Lake Burullus.
Ecology: Crepuscular. It feeds on insects and small invertebrates.
Status: Lower Risk (Least concern).

Class: Reptilia

Order: Squamata

Suborder: Sauria

Family: Gekkonidae

***6- Hemidactylus turcicus* (Linnaeus, 1758).**
Common name: Turkish or Warty or Mediterranean Gecko; برص منزلى

World distribution: North Africa.
National distribution: Suitable localities throughout Egypt and Sinai.
Burullus observation sites: Burg El-Burullus and near El-Tolombat.
Habitat: It is mostly found on rocks and it also frequents on walls of old buildings.
Ecology: It occurs mostly in contact with human settlement. In Egypt, it is the most common house gecko. For more details see Saber (1999).
Status: Lower Risk (Least concern).

Family: Lacertidae

***7- Acanthodactylus boskianus asper* (Daudin, 1802).**
Common name: Bosc's Lizard; سقنقر خشن
World distribution: Widespread throughout North Africa and southwestern Asia.

National distribution: Common throughout desert areas and margins of Nile Valley and Delta.
Burullus observation sites: Burg El-Burullus, El-Aaqula, near El-Hanafy, El-Maqsaba and Mastaroah.
Habitat: Sparsely vegetated areas with gravel and stones, but less on sand.
Ecology: A diurnal species, feeds on a variety of food items. Detailed information are found in Sadek (1992), Bashandy *et al.* (1994), Saber (1999) and Saber *et al.* (1994)
Status: Lower Risk (Least concern).

***8- Acanthodactylus schreiberi* Boulenger, 1878.**
World distribution: Cyprus, Palestine and Lebanon.
Burullus observation sites: El-Aaqula
Habitat: Sandy vegetated areas.
Ecology: A diurnal species feeds on insects. This species was added to the herpetofauna for the first time according to the specimen collected from a sandy vegetative area near El- Hanafy village.
Status: Not evaluated.
Remarks: The finding of new records indicates that more additional efforts are required for the study of the herpetofauna of the area.

***9- Acanthodactylus scutellatus scutellatus* (Audouin, 1829).**
Common name: Nidua Lizard; سقنقر الرمل الكبير
World distribution: North Africa to southwestern Asia.
National distribution: Western, Eastern and Sinai deserts.
Burullus observation sites: El-Aaqula and near Mastaroah
Habitat: Open sandy desert.
Ecology: A diurnal species, feeds on small insects (Saber 1989).
Status: Lower Risk (Least concern)

***10- Acanthodactylus* sp.**
One specimen of unidentified species from genus *Acanthodactylus* was collected.
Burullus observation sites: El-Aaqula and near Mastaroah.
Habitat: stony vegetated areas.
Ecology: A diurnal species feeds on insects.
Status: Not evaluated.
Remarks: More scientific efforts, library and museum visits are required for solving some taxonomic problems.

Family: Scincidae

***11- Chalcides ocellatus ocellatus* (Forskal, 1775).**

Common name: Eyed Skink; Ocellated Skink; سحلية دفانة

World distribution: North Africa to southeastern Europe and southwestern Asia.

National distribution: Throughout desert areas, Mediterranean coastal desert of Egypt and Sinai.

Burullus observation sites: near El-Tolombat.

Habitat: Sandy desert, it may inhabit also banks of irrigation canals.

Ecology: It is crepuscular, semifossorial, living under sand or dead vegetation.

Status: Lower Risk (Least concern).

***12- Mabuya vittata* (Olivier, 1804)**

Common name: Bridled Skink; سحلية جراية مخططة

World distribution: North Africa and southwest Asia.

National distribution: Northern Delta and coastal areas of northern Sinai.

Burullus observation sites: Al-Kawm Al-Akhdar and Deshimi Islets. It is also collected from a site just east of the study area.

Habitat: Sandy desert with dense vegetation.

Ecology: A diurnal, but spends the hottest hours of the day in its burrow. It digs burrows between the roots of the vegetation.

Status: Lower Risk (Least concern).

***13- Mabuya quinquetaeniata quinquetaeniata* Lichtenstein, 1823**

Common name: Bean Skink; سحلية جراية

World distribution: North of Uganda to Egypt.

National distribution: Throughout Nile Valley and Delta and adjacent reclaimed cultivated land.

Ecology: This is the most common lizard in Nile Valley. It inhabits gardens and other green areas within towns and villages. It is also common in wild vegetation along irrigation canals and the banks of River Nile. It is active during the day and feeds on a variety of insects.

Status: Low Risk (least concern)

***14- Sphenops sepsoides* (Audouin, 1827).**

Common name: Audouin's Sand-Skink; سحلية نعامة

World distribution: North Africa to southwest Asia.

National distribution: Western, Eastern and Sinai deserts.

Burullus observation sites: Al-Kawm Al-Akhdar islet.

Habitat: Fine sand desert and sand dunes.

Ecology: A sand-dwelling, fossorial species, digs mainly around plant roots, locate insects on the sand and move about on the surfaces.
Status: Lower Risk (Least concern).
Remarks: This record is the first of this species in the whole Delta, and this species is not found in any other site in the whole Delta outside this islet.

Family: Chamaeleontidae

***15- Chamaeleo chamaeleon chamaeleon* (Linnaeus, 1758).**
Common name: Common Chamaeleon; European Chamaeleon; حرباء
National distribution: Western Mediterranean coastal desert, south to Moghra and Wadi El-Natrun and northern part of the Eastern Desert.
World distribution: South Europe, North Africa, and southwest Asia.
Burullus observation sites: near Mastaroah.
Habitat: Vegetated desert area with bushes or trees.
Ecology: Arboreal species found on trees and bushes, when food becomes scarce they move away, even on the ground.
Status: Lower Risk (Least concern).

***16- Chamaeleo africanus* Laurenti, 1768.**
Common name: African Chamaeleon; حرباء خضراء
World distribution: Egypt southward to Sudan, Eritrea and Somaliland westward to west Africa.
National distribution: Nile Valley and Delta
Burullus observation sites: near Shabab El-Kharrigeen land.
Habitat: Humid and vegetated areas.
Ecology: Arboreal, found on trees and bushes and territorial species.
Lower Risk (Least concern).

Suborder: Serpents

Family: Boidae.

***17- Eryx jaculus jaculus* (Linnaeus, 1758).**
Common name: Javelin Sand-Boa; دساس بلدى
World distribution: North central Africa, eastward into southwestern Asia to Caspian Sea.
National distribution: Mediterranean coastal desert, Nile Delta and lower Valley, and northern Sinai.
Burullus observation sites: (Saleh & Saber 1992, Saleh 1997).
Habitat: Sandy areas near cultivated land.
Ecology: A strictly nocturnal snake feeding mostly on ground dwelling geckoes.
Status: Endangered.

Family: Elapidae.

***18- Naja haje haje* (Linnaeus, 1758)**

Common name: Egyption Cobra; كوبرا مصرى

World distribution: Africa.

National distribution: Nile Valley and Delta, El-Faiyum and Western Mediterranean coastal desert.

Ecology: Inhabits agricultural fields of Nile Delta and Valley or vegetated areas in the western Mediterranean coastal desert. It is most frequently encountered on densely vegetated banks of the river or irrigation canals. It is a diurnal snake that feeds mostly on frogs but may also take rodents or other snakes.

Status: Low Risk (least concern).

Remarks: An aggressive snake, attacking viscously when cornered. Egyptian Cobra is a very dangerous snake in view of its aggressive nature and its potent venom which it produces in large quantities (Saleh 1997)

Family: Coluberidae

***19- Malpolon monspessulana insignita* (Geoffroy St. Hilaire, 1809).**

Common name: Montpelier Snake; ثعبان خضارى

World distribution: North Africa and southwest Asia.

National distribution: Western Mediterranean coastal desert, Nile Delta and lower Valley and Siwa Oasis.

Burullus observation sites: Burg El-Burullus, El-Aaqula, near El-Hanafy, Mastaroah, Al-Kawm Al-Akhdar and Deshimi Islets

Habitat: sandy areas of northern coast around vegetated salt marshes and cultivated land.

Ecology: Diurnal, but crepuscular and nocturnal activity during the hottest months. Feeds on a variety of food items including lizards, snakes, birds and rodents. Cannibalism case was recorded in captivity in surprising fashion by taking the prey from its tail. Activity pattern and thermal ecology in thermal gradient were studied (Saber and Abd Al Rahiem, unpuplished records).

Status: Lower Risk (Least concern).

***20- Natrix tessellata tessellata* (Laurenti, 1768).**

Common name: Diced Water Snake; ثعبان الماء

World distribution: Europe or the eastern Africa, south western and central Asia.

National distribution: Nile Delta, lower valley, El-Faiyum and Fuweila in Sinai.

Burullus observation sites: near Shabab El-Kharrigeen land.

Habitat: Near fresh water streams and irrigation canals.

Ecology: Aquatic snake feeds on fishes and amphibians.
Status: Lower Risk (Least concern).

***21- Psammophis sibilans sibilans* (Linnaeus, 1758).**
Common name: African Beauty Snake; أبو السيور
World distribution: Africa and India.
National distribution: Nile Valley, Delta and El-Faiyum.
Burullus observation sites: near El-Tolombat and near Shabab El-Kharrigeen land.
Habitat: Gardens and cultivated areas.
Ecology: Diurnal snake which may climb trees. Feeds mainly on lizards and rodents. Its venom is usually not dangerous, nevertheless the bite of large specimens can sometimes induce painful symptoms for some days.
Status: Lower Risk (Least concern).

***22- Coluber florulentus* Geoffroy, 1827**
Common Name: Flowered Snake; أزرود
World distribution: Northeast Africa.
National distribution: Nile Valley and Delta, El-Faiyum and Wadi El Natrun
Ecology: Inhabits areas with wild vegetation around cultivated land, near irrigation canals and often in village houses. It feeds on frogs and possibly lizards.
Status: Low Risk (least concern).

Order: Testudines
Family: Testudinidae
***23- Caretta caretta* (Linnaeus, 1758)**
Common name: Loggerhead Turtle; ترسة
World distribution: African Mediterranean coasts, Indian and Atlantic Oceans.
National distribution: Mediterranean Sea near Balttim and Red Sea at Ras Muhammad and near the northern tip of Aqaba Gulf.
Burullus observation sites: This species is well known from the area (Flower 1933; Saleh and Saber 1992, Saleh 1997).
Habitat: Wide migrations in oceans, but also entering river mouths and lagoons
Ecology: It is omnivorous turtle feeds on sponges, jelly fish, molluscs, tunicates, crustaceans, fish and also sea weeds.
Status: Endangered.

Family *Cheloniidae*

***24- Chelonia mydas* (Linnaeus, 1758)**

Common Name: Green Turle; سلحفاة بحرية خضراء

World distribution: Tropical, subtropical and temperate seas, including all African coasts, Indian Pacific and Atlantic Oceans.

National distribution: Egyptian coastal waters including Mediterranean and Red Seas.

Ecology: Feeding areas are shallow coastal sites with extensive growths of algae and seagrasses. The main food of the Green Turtle is seagrasses and algae; although jellyfish, mollusks, crustaceans and sponges are occasionally eaten. They nest on gently slopping sandy beaches at a relatively few sites throughout the world. They may disperse great distances from breeding site to feeding areas.

Status: Endangered.

Remarks: The main threat to this and other marine turtles, are the human activities. Destruction of nesting grounds caused by different coastal developments, including land filling of shallow coastal areas are adversely affecting this species in Egypt. Water pollution with oil and other pollutants appears to have had a significant negative impact on its populations worldwide (Saleh 1997). The population of the green turtle in the Atlantic Ocean, as well as most of the Indo-Pacific is assigned to subspecies *C. mydas mydas*, while *C. mydas agassizii* is recognized as the form that distributed in the eastern Pacific Ocean

11.7. SUMMARY

Twenty three species of reptiles and amphibians have been reported from Burullus Protected Area, consisting of nine lizards, six snakes, two marine turtles and five amphibians . The herpetofauna is abundant and moderately diverse. The number of amphibian species and their relative abundance is notably high (five out of eight Egyptian amphibians), reflecting the availability of freshwater wetland habitats. The most common species are Bosc's Fringe-Toed Lizard *Acanthodactylus boskianus*, Egyptian Toad *Bufo regularis* and Mascarene Frog *Ptychadena mascareniensis*. The recently described Nile Valley Toad *Bufo kassasii* is an Egyptian endemic, found in localized, but dense populations in suitable freshwater swamps along the southern margins of the Protected Area. The species is thus far only known from Nile Valley in Egypt. It is not under any immediate threat, and is expanding its range in Egypt. Two globally threatened reptile species have been recorded in Burullus Protected Area; Loggerhead turtle *Caretta caretta* (Endangered) and Green turtle *Chelonia mydas* (Endangered). The Javelin Sand Boa *Eryx jaculus* is the most threatened species at the local level.

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11.9. PLATES OF HERPETOFAUNA (11.1 – 11.9)

(after Mikhail 2003; Website: www.gescities.com/herpetology_bg/contents.htm)

Plate 11.1
Bufo regularis
Ptychadena mascareniensis

Plate 11.2
Bufo kassasii
Bufo viridis

Plate 11.3
Rana ridibunda
Hemidactylus turcicus

Plate 11.4
Acanthodactylus scutellatus
Chalcides ocellatus

Plate 11.5
Mabuya vittata
Sphenops sepsoides

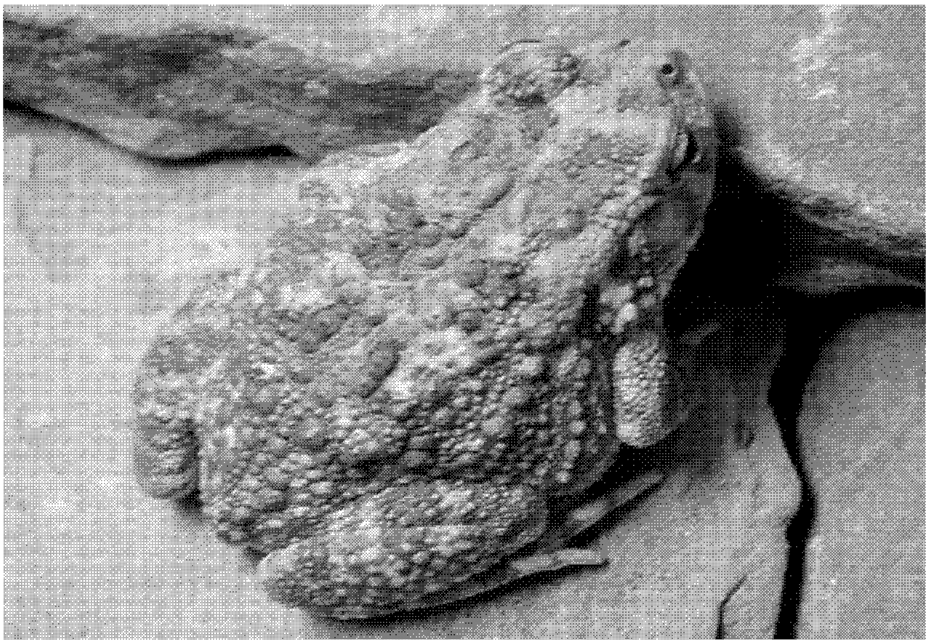
Plate 11.6
Chamaeleo chamaeleon
Chamaeleo africanus

Plate 11.7
Eryx jaculus
Malpolon monspessulana

Plate 11.8
Natrix tessellata
Psammophis sibilans

Plate 11.9
Caretta caretta
Chelonia mydos

Plate 11.1



Bufo regularis ضفدع نيلى

Ptycadena mascareniensis جزاع ابو خطين

Plate 11.2

Bufo kassasii ضفدع قصاص

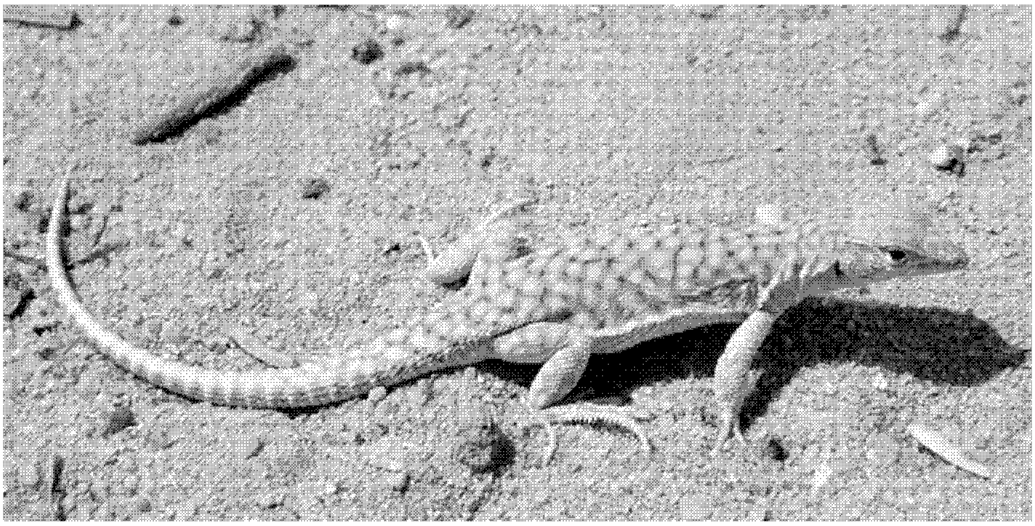
Bufo viridis ضفدع اخضر

Plate 11.3

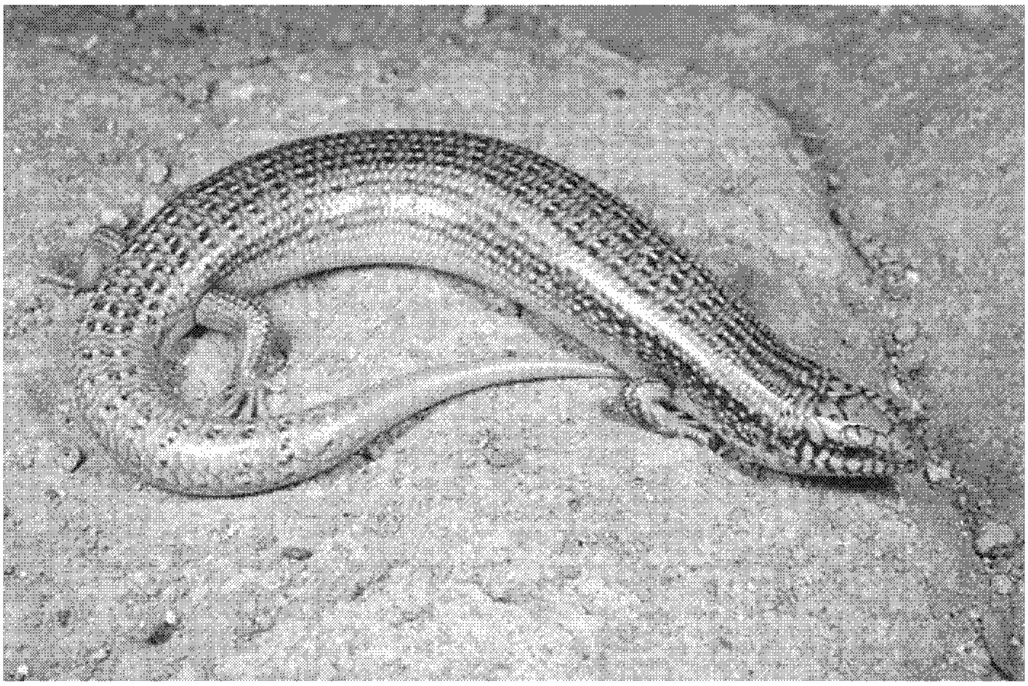
Rana ridibunda جزاع اخضر

Hemidactylus turcicus برص منزلى

Plate 11.4



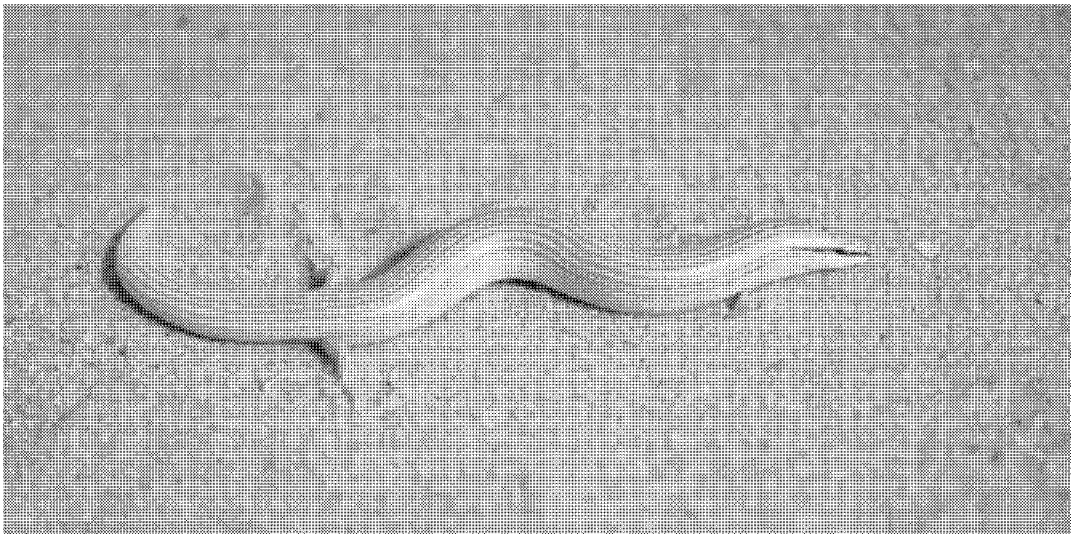
Acanthodactylus scutellatus سقنقر الرمل الكبير



Chalcides ocellatus سحلية دفانة

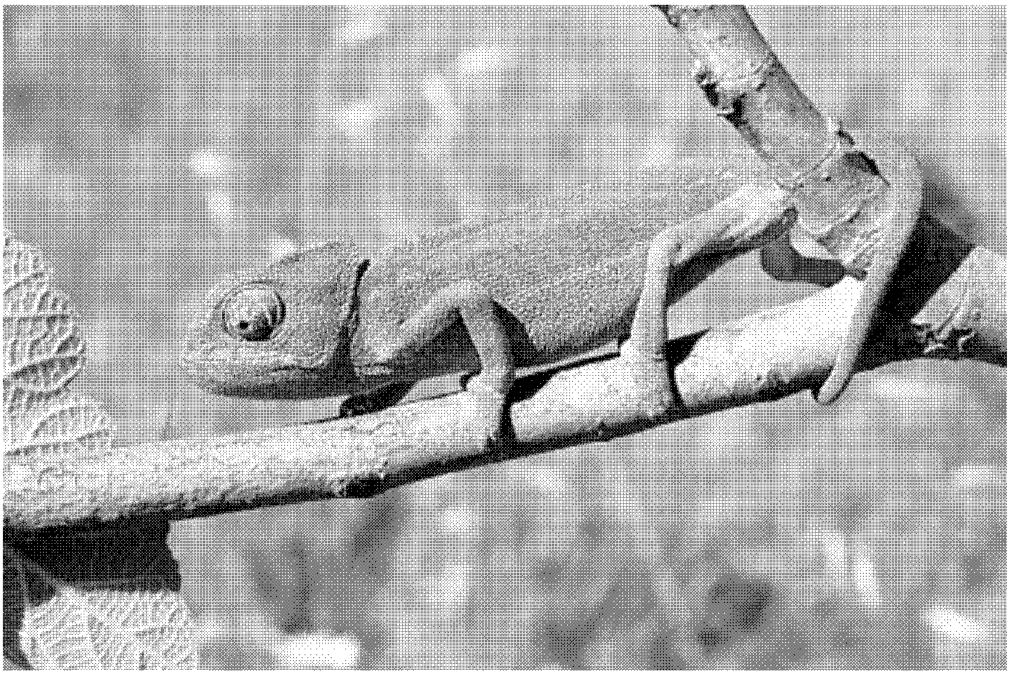
Plate 11.5

Mabuya vittata سحلية جراية مخططة

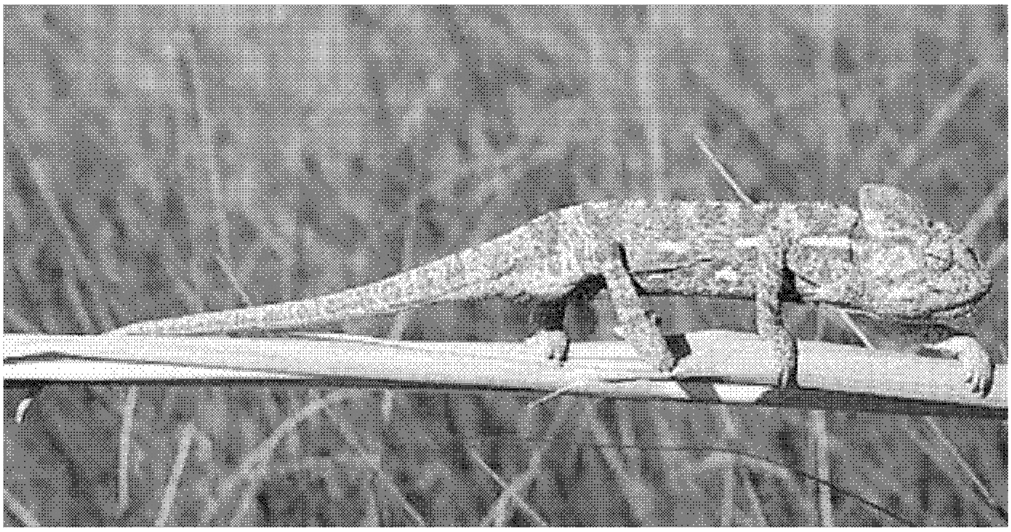


Sphenops sepsoides سحلية نعامة

Plate 11.6

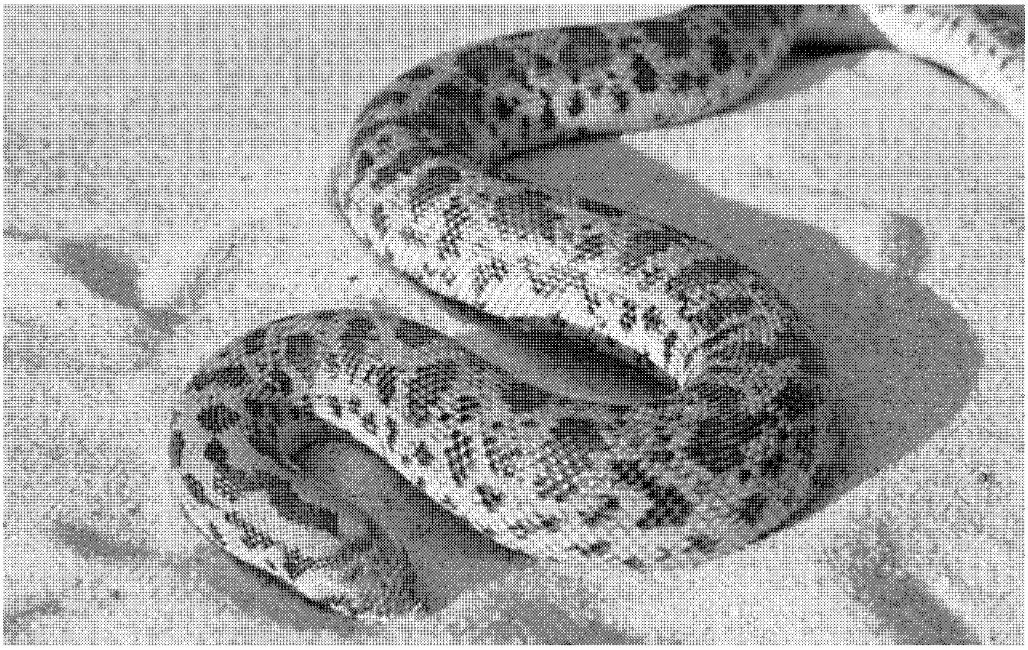


Chamaeleo chamaeleon حرباء

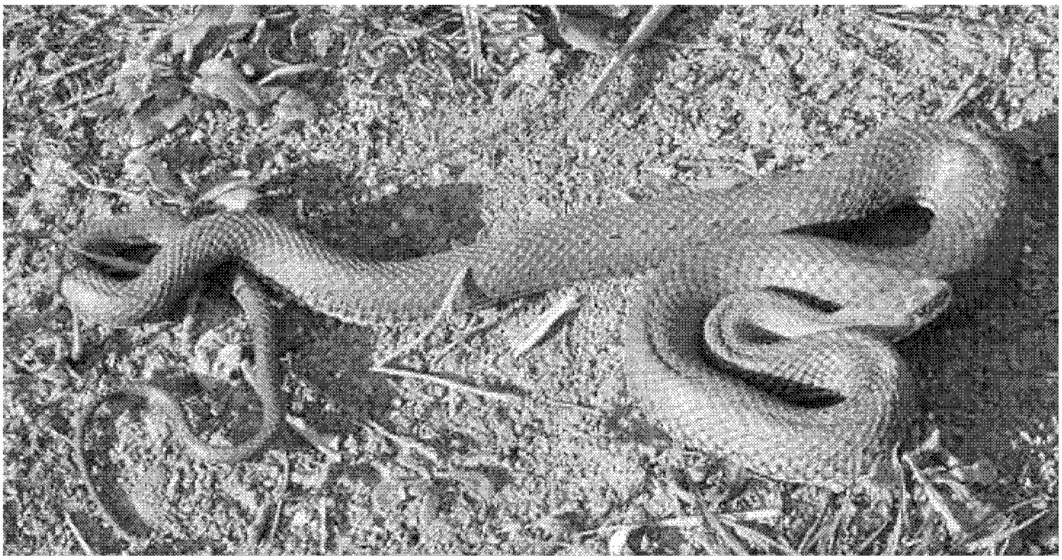


Chamaeleo africanus حرباء افريقية

Plate 11.7

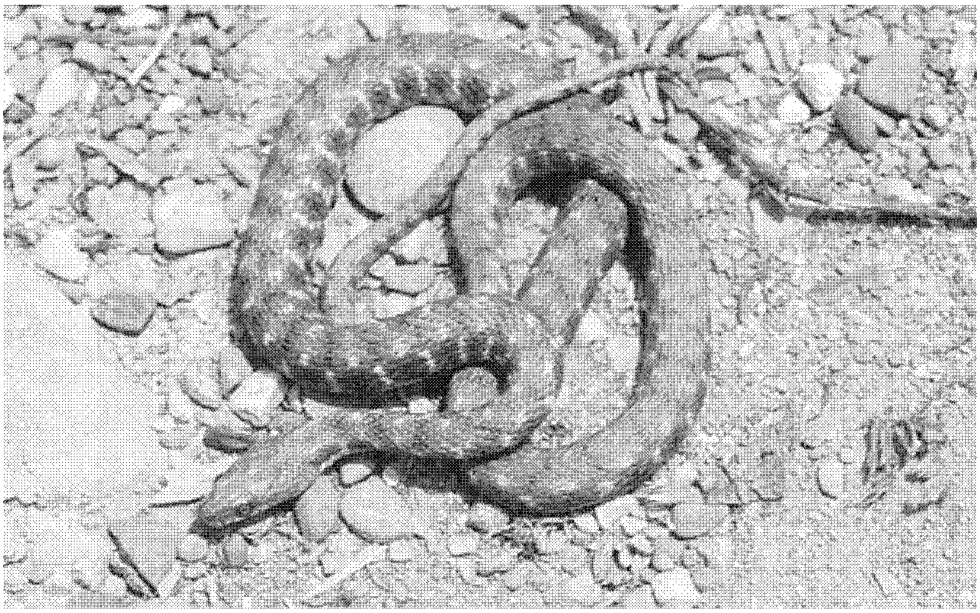


Eryx jaculus jaculus دساس بلدى

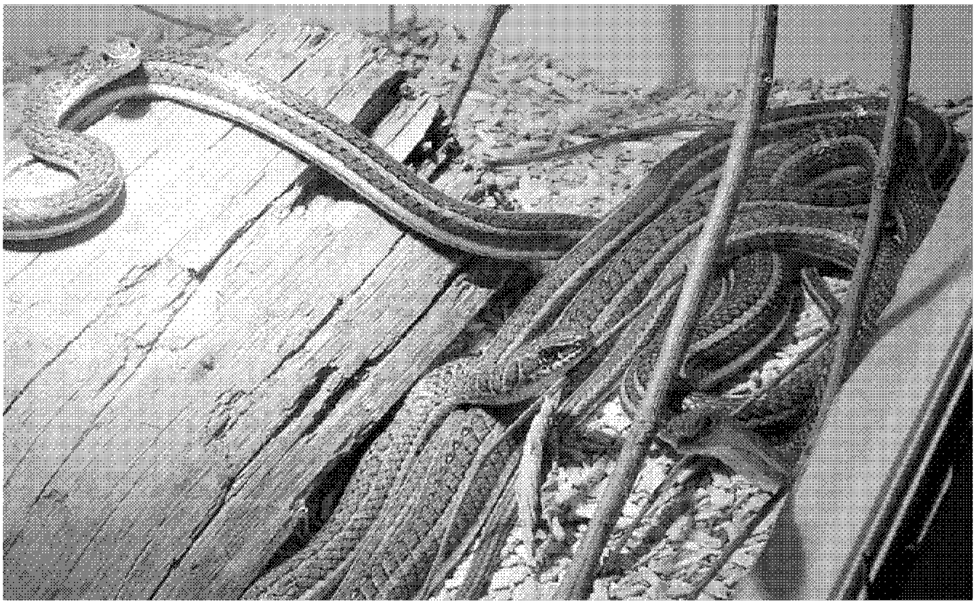


Malpolon monspessulanus ثعبان خضارى

Plate 11.8

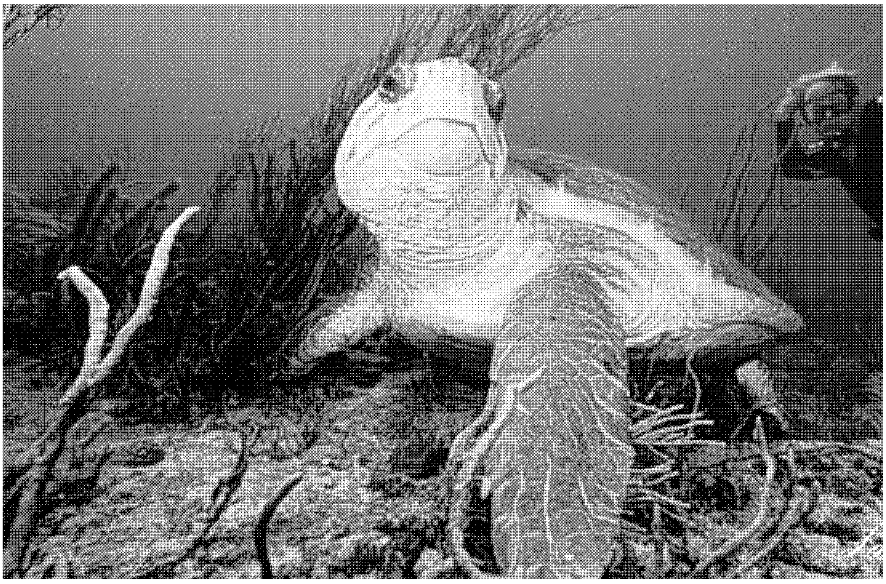


Natrix tessellate ثعبان الماء

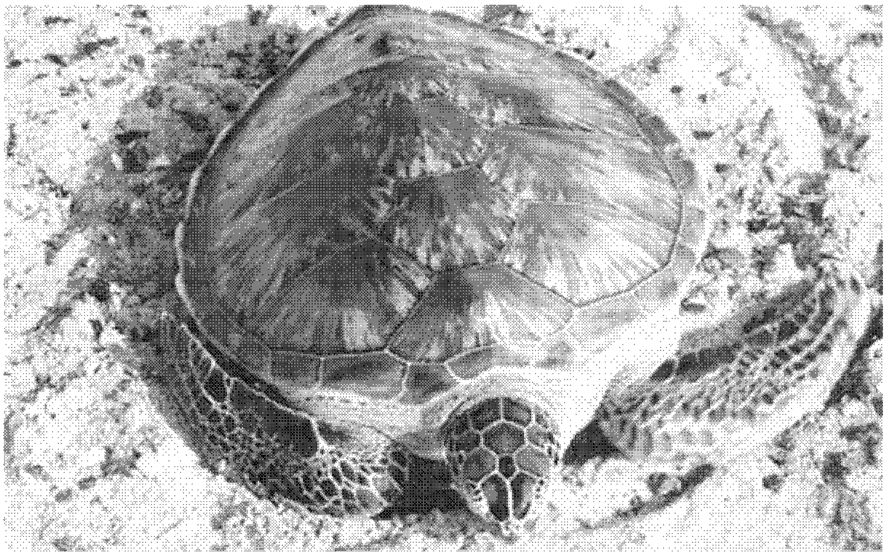


Psammophis sibilans أبو السيور

Plate 11.9



Caretta caretta ترسة



Chelonia mydos سلحفاة بحرية خضراء

Chapter 12
Birds

12.1. HABITATS SUPPORTING WATER BIRDS

Habitats inside Lake Burullus may be roughly classified into four categories: 1- reedbeds, 2- marshes with halophytes, 3- open water with submerged vegetation, 4- areas with very low water levels and emergent sand or mud-flats with scarce or no vegetation. On the edges of the wetland there are sand dunes between the sea and the lake, and man-made habitats such as canals and drains, arable land and fish-farms. The breeding population of Pied kingfisher (*Ceryle rudis rudis*) of the lake is gathered mainly along the banks of the surrounding canals. Fish-farms may be of interest only for fish-eating birds like herons, gulls and terns during winter and passage periods (Tinarelli 1994).

12.1.1. Reedbeds and Marshes

Reedbeds within the lake are estimated to cover about 7000 hectares (Shaltout *et al.* 2004) and represent one of the most important reedbeds in the Mediterranean region where this type of habitat is becoming more and more rare and threatened. The largest reedbeds are mainly in the middle-southern and eastern parts (between Elshkloba and Baltim), but many wide reed-belts are present along the western and the northern shores of the lake. The surface covered with reed beds had increased strongly in the past decades due both to marked increase of freshwater with heavy fertilizer loads brought by drainage canals, and to frequent clogging of the connection with sea. At present, the growth of the reedbeds, seems stable, or even retreats.

Wintering and migrant birds like Squacco Heron (*Ardeola ralloides*), Marsh Harrier (*Circus aeruginosus aeruginosus*) and many passerines are strongly dependent on reedbeds for foraging and refuge. Reedbeds provide also important breeding habitat for the rare Purple Gallinnule (*Porphyrio porphyrio*

madagascariensis), Little Bittern (*Ixobruchus minutus minutus*), Moorhen (*Gallinula chloropus chloropus*), Water Rail (*Rallus aquaticus aquaticus*) and Clamorous Reed warbler (*Acrocephalus stentoreus stentoreus*). Small open waters inside the reedbeds are feeding and resting sites for Ferruginous Duck (*Aythya nyroca*). Red-Crested Pochard (*Netta rufina*) and less frequently for other dabbling ducks.

12.1.2. Areas of Low Water Levels and Exposed Sand/Mud Flats

Areas of low water levels and exposed sand / mud flats with scarce or no vegetation are mainly in the northeastern sector where the reed growth is limited by salt-water entering from the sea. The presence of this habitat is very important for the lake because it supports foraging wintering and migrant waders. Emergent sand-flats and mud-flats are used also by wintering and migrant terns and gulls (especially Little Gull *Larus minutus* and Whiskered Tern *Chlidonias hybrida hybrida*) and herons (especially Little Egret *Egretta garzetta garzetta*) as resting site. Small areas of mud-flats with scarce or no vegetation are present inside some islets and represent suitable habitats for breeding of Collared Pratincola (*Glareola pratincola partincola*), Kentish Plover (*Charadrius alexandrinus alexandrinus*), Kittlitz's Plover (*Charadrius pecuarius allenbyi*) and Little Tern (*Sterna albifrons albifrons*).

12.1.3. Open Water with Submerged Vegetation

Open water with submerged vegetation is the feeding and resting habitat for wintering and migrant ducks and coots. Most eutrophicated area with presence of insects on water surface, generally near reedbeds, are used as foraging sites by Little Gulls (*Larus minutus*) and Whiskered Tern (*Chlidonias hybrida hybrida*). Marshes with halophytic vegetation are present both inside many islets due to salted soils, and along the southern shore in areas formerly used for commercial salt production and fish farming. Spur-winged Plover (*Hoplopterus spinosus*) uses this type of habitat for breeding, while wintering and migrant raptors, waders, Great White Egret (*Egretta alba alba*) and Little Egret (*Egretta garzetta garzetta*) use it for feeding (Tinarelli 1994).

12.2. BREEDING BIRDS

Breeding water birds in Lake Burullus include Little Grebe (fairly common), Little Bittern (probably hundreds of pairs), Water Rail (fairly common), Moorhen (common), Purple Gallinule (common; together with Lake Manzala probably they are the most important breeding sites in the Western Palearctic), Painted Snipe (locally southern shore), Collared Pratincole (at least 2000 pairs along the southern shore in 1992, one of the most important breeding areas in the Western Palearctic), Kittlitz's Plover (scarce; southern shore), Kentish Plover (common; over 300 pairs in 1992); Spur-winged Plover (fairly common) Little Tern (common; over 500 pairs in

1992). Reedbeds and salt marshes hold a variety of other breeding species including Senegal Coucal (fairly common), Pied Kingfisher, Lesser Short-toed Lark, Fan-tailed Warble, Graceful Warbler, Clamorous Reed Warbler and Streaked Weaver (Meininger & Atta 1994).

The reedbeds of Lake Burullus undoubtedly hold one of the largest populations in the Western Palearctic of Little Bittern, Purple Gallinule and Clamorous Reed Warbler. The only western Palearctic population of Painted Snipe and Senegal Coucal are found in Egypt. The salt marshes around Lake Burullus are of major importance for two subspecies endemic to Egypt; Lesser Short-Toed Lark *Calandrella rufescens nicolli* which is only known from north Nile Delta, and Egyptian wagtail *Motacilla flava pygmaea* which is only known from the Nile Delta and Valley. Lake Burullus may well be the stronghold of *Calandrella rufescens nicolli* (Goodman *et al.* 1989, Meininger & Atta 1994).

The breeding bird community in the lakes of north Nile Delta can be grouped in to 2 groups: species breeding solitary in the cover of reedbeds, and species breeding in the extensive salt marshes and sparsely vegetated sandflats. The absence of species breeding in large colonies (e.g. herons) is striking, and is probably an indication of the level of human disturbance. The absence of the breeding species Great-Crested Grebe and Coot, both characterized by easily detectable nests, may also be related to disturbance. Proper management that leads to reduction of the direct disturbance in some selected areas in the lake, would undoubtedly have immediate positive effects on the numbers of the breeding waterbirds (Meininger & Atta 1994).

12.3. BIRD SURVEYS

Considering the geographical position and the present habitat types, Lake Burullus is most likely of major importance for waterbirds, especially herons, ducks, waders, gulls and terns (Goodman *et al.* 1989, Tharwat 1997, Baha El-Din 1999). There is virtually no data on the function of Lake Burullus as a staging area for birds during spring and autumn migration. Apart from winter surveys, the only reasonably complete census of waterbirds was made on November 1981 (Bennett *et al.* 1982). Since that census was carried out after the main autumn migration period of most waterbirds between Eurasia and sub-saharan Africa, and before the main winter influx of ducks and coot, numbers of most species observed were lower than in winter. The numbers of Shoveler (2100), Tufted Duck (13400), Ferrugineous Duck (100), Coot (64000), and Whiskered Tern (3000) were noteworthy. The marshy areas are undoubtedly of importance for enormous number of passerines during migration.

Four winter surveys (1978/79, 1979/80, 1989/90 and 1994) were carried out for the birds of Lake Burullus (Meininger & Atta 1994 and Tinarelli 1994). An autumn survey was recently carried out in 2000 by Tharwat and Hamied

(2000). One hundred and twelve bird species and subspecies were recorded in these surveys (Table 12.1), they represent 21.7 % of the total avifauna of Egypt (515 species and subspecies, as reported by Tharwat 1997). During these four winter surveys, there was a remarkable increase in species richness associated with a sharp decrease in the community density (Fig. 12.1) This was due to the dramatic decrease in the density of some populations such as those of Coot (*Fulica atra atra*), Shoveler (*Anas clypeata*), Black Headed Gull (*Larus ridibundus*), Pochard (*Aythya ferina*) and Ferruginous Duck (*Aytha nyrrca*). Some other populations had an increased density with time (Fig. 12.2) such as Kentish Plover (*Charadrius alexandrinus alexandrinus)*, Little Stint (*Calidris minuta*) and Pied Kingfisher (*Ceryle rudis rudis*). It is of interest to indicate that, 18 of the 53 species recorded during autumn by Tharwat and Hamied (2000), were not recorded in any of the previous winter surveys. This means that a complete annual survey, based on monthly or seasonal intervals, will lead to give a reasonable evaluation about the species richness of avifauna in Lake Burullus.

Of the 112 bird species and subspecies recorded in Lake Burullus: 46 are residents, 80 are winter visitors, 23 are spring visitors, and 72 are both summer and autumn passers (Table 12.2). The collection of information about the national and world distributions of these birds indicates the possibility of occurrence of 8 endemic species and sub-species (Table 12.3):

1	*Charadrcus pecuarius allenbyi*	(Kittlitz's Plover)	قطقاط بنى
2	*Streptopelia senegalensis aegyptiaca*	(Palm Dove)	يمام بلدى
3	*Centropus senegalensis aegyptius*	(Senegal Coycal)	كوكو –سمك
4	*Calandrella rufescens nicolli*	(Lesser Short-Toed Lark)	قنبرة قصيرة الأصابع
5	*Galerida cristata nigricans*	(Crested Lark)	قنبرة بشوشة
6	*Prinia gracilis deltae*	(Graceful Warbler)	هازجة –فصية
7	*Motacilla flava pygmaea*	(Egyptian Wagtail)	ابوفصادة مصرى
8	*Merops orientalis cleopatra*	(Little Green Bee-eater)	وروار – خضير

Table 12.1. **List of the bird species recorded in Lake Burullus based on four winter censuses extended from 1978 to 1994 and an autumn census in 2000. The first three censuses are those of Meininger & Atta (1994), the fourth is that of Tinarelli (1994), and the fifth is that of Tharwat and Hamied (2000). * : Denotes the endemic species, ** : the extinct species, b: breeding species.**

No.	Scientific name	Family	English name	Arabic name	Number				
					78/79	79/80	89/90	94	2000
1	*Gavia arctica arctica***	Gaviidae	Black Throated Diver	الغواص أسود الزور	-	-	2	-	-
2	*Tachybaptus ruficollis ruficollis*[b]	Podicipediae	Little Grebe	زهوت	-	2	2	-	14
3	*Podiceps cristatus cristatus*	Podicipediae	Great Creasted Grebe	غطاس متوج	17	-	22	-	-
4	*Podiceps nigricollis nigricollis*	Podicipedidae	Black-Necked Grebe	غطاس أسود الرقبة	17	-	22	20	-
5	*Phalacrocorax carbo sinensis*	Phalacrocoracidae	Cormorant	غراب البحر ــ أبو غطاس	-	-	1	85	-
6	*Ardea cinerea cinerea*	Ardeidae	Grey Heron	بلشون رمادى	1	2	65	-	40
7	*Ardeola ralloides*	Ardeidae	Squacco Heron	واق أبيض	-	-	143	94	289
8	*Nycticorax nycticorax nycticorax*	Ardeidae	Night Heron	غراب الليل – واق الشجر	-	-	-	-	13
9	*Ixobruchus minutus minutus*[b]	Ardeidae	Little Bittern	واق صغير ــ مليحة	-	4	14	-	15
10	*Egretta alba alba*	Ardeidae	Great White Egret	بلشون أبيض كبير	3	-	58	19	-
11	*Egretta ibis ibis*	Ardeidae	Cattle Egret	أبو قردان ــ غرنوج	-	-	250	12	312
12	*Egretta garzetta garzetta*	Ardeidae	Little Egret	بلشون أبيض ــ أبو بليقة	-	372	310	304	519
13	*Phoenicopterus ruber roseus*	Phoenocopteridae	Greater Flamingo	بشاروش ــ نحام	-	-	22	-	-
14	*Tadorna tadorna*	Anatidae	Common Shelduck	شهرمان	-	-	17	-	-
15	*Anas platyrhynchos platyrhynchos*	Anatidae	Mallard	خضارى	407	15	1312	2	-
16	*Anas crecca crecca*	Anatidae	Green Winged Teal	شرشير شتوى	622	62	2094	-	-
17	*Anas strepera strepera*	Anatidae	Gadwall	سمارى	235	32	-	-	-
18	*Anas penelope*	Anatidae	European Wigeon	صواى	23400	35604	19018	32	-
19	*Anas clypeata*	Anatidae	Shoveler	كيش	63458	53055	15427	300	+
20	*Anas querquedula*	Anatidae	Garganey	شرشير صيفى	-	-	-	-	177

Table 12.1. cont. 1.

No.	Scientific name-	Family	English name	Arabic name	Number				
					78/79	79/80	89/90	94	2000
21	*Netta rufina*	Anatidae	Red-Crested Pochard	ونس	70	7	7	2	-
22	*Aythya ferina*	Anatidae	Pochard	حمراى	8316	8205	7357	220	-
23	*Aytha nyroca*	Anatidae	Ferruginous Duck	زرقاى أخضر	6582	960	576	120	-
24	*Aytha fuligula*	Anatidae	Tufted Duck	زرقاى	23	9	11	3	-
25	*Elanus caeruleus caeruleus*	Accipitridae	Black-Shouldered Kite	كوهية ــ حداية	-	-	-	4	5
26	*Circus cyaneus cyaneus*	Accipitridae	Hen Harrier	أبو حسن ــ عقاب الدجاج	-	-	-	2	-
27	*Circus aeruginosus aeruginosus*	Accipitridae	Marsh Harrier	دراع	-	-	-	29	-
28	*Circus pygargus*	Accipitridae	Montagu's Harrier	أبو شردة	-	-	-	-	1
29	*Falco tinnuniculus tinnuniculus*	Falconidae	Kestrel	عوسق	-	-	-	3	325
30	*Rallus aquaticus aquaticus*[b]	Rallidae	Water Rail	مرعة الماء ــ كلب الماء	-	5	11	5	-
31	*Porzana porzana*	Rallidae	Spotted Crake	مرعة منقطة	-	3	-	-	-
32	*Gallinula chloropus chloropus*[b]	Rallidae	Moorhen	دجاجة الماء	5	22	39	++	27
33	*Porphyrio porphyrio madagascariensis*[b]	Rallidae	Purple Gallinule	دجاجة سلطانية	-	5	10	3	7
34	*Fulica atra atra*	Rallidae	Coot	غر	153525	101500	15790	7132	5
35	*Rostratula benghalensis benghalensis*[b]	Rostratulidae	Painted Snipe	بكاشين مزوق ــ شنقب	-	-	-	-	-
36	*Himantopus himntopus himntopus*	Recurvirostridae	Black Winged Stilt	أبو المغازل ــ أبو قصبة	-	-	11	-	-
37	*Recurvirostra avosetta*	Recurvirostridae	Pied Avocet	حليبى ــ نكات	-	25	2949	7	1
38	*Glareola pratincola pratincola*[b]	Glareolidae	Collared Pratincole	أبو اليسر	-	-	-	-	-
39	*Charadrius hiaticola tundrae*	Charadriidae	Ringed Plover	قطقاط متوج كبير ــ زقزاق	-	199	179	844	120
40	*Charadrius dubius curonicus*	Charadriidae	Little Ringed Plover	قطقاط متوج صغير	-	-	-	1	-
41	*Charadrius pecuarius allenbyi**[b]	Charadriidae	Kittlitz's Plover	قطقاط بنى	-	-	-	3	-
42	*Charadrius alexandrinus alexandrinus*[b]	Charadriidae	Kentish Plover	قطقاط أبو الرؤوس	-	590	617	1178	10
43	*Charadrius leschenaultii*	Charadriidae	Greater Sand Plover	قطقاط الرمل الكبير	-	33	24	4	10
44	*Pluvialis squatarola*	Charadriidae	Grey Plover	قطقاط رمادى	2	28	25	-	-
45	*Vanellus Vanellus*	Charadriidae	Lapwing	زقزاق شامى	45	75	9	50	-
46	*Chettusia leucura*	Charadriidae	White-Tailed Plover	زقزاق أبيض الذنب	-	-	-	2	-
47	*Hoplopterus spinosusb*	Charadriidae	Spur-Winged Plover	زقزاق ــ أبو زفر	7	4	48	113	126

Table 12.1. cont. 2.

No.	Scientific name	Family	English name	Arabic name	Number				
					78/79	79/80	89/90	94	2000
48	*Calidris alba*	Scolopacidae	Sanderling	مدروان	-	-	-	3	-
49	*Calidris temminckii*	Scolopaci	Temminck's Stint	فطيرة تمنك	-	-	4	-	-
50	*Calidris ferruginea*	Scolopacidae	Curlew Sandpiper	دريجة كروانية	-	-	-	18	-
51	*Calidris minuta*	Scolopacidae	Little Stint	كروان الماء	60	756	784	1030	130
52	*Calidris alpina alpina*	Scolopacidae	Dunlin	دريجة	2	684	30	330	62
53	*Philomachus pugnax*	Scolopacidae	Ruff	بياض ـــ حجوالة	235	-	-	7	3
54	*Lymnocryptes minimus*	Scolopacidae	Jack Snipe	بكاشين صغير	-	-	-	-	2
55	*Gallinago galinago galinago*	Scolopacidae	Snipe	بكاشين ـــ شنقب	2	18	53	1	-
56	*Limosa limosa limosa*	Scolopacidae	Black-Tailed Goduit	بقويقة سوداء الذنب	-	-	161	21	-
57	*Limosa lapponica lapponica*	Scolopacidae	Bar-tailed Godwit	بقويقة مخططة الذنب	-	-	-	-	1
58	*Numenius arquata arquata*	Scolopacidae	Common Curlew	كروان الغيط	-	-	15	-	-
59	*Tringa erythropus*	Scolopacidae	Spotted Redshank	طيطوى أحمر الساق أرقط	1	-	2	4	-
60	*Tringa totanus totanus*	Scolopacidae	Redshank	طيطوى أحمر الساق	522	137	3670	885	144
61	*Tringa nebularia*	Scolopacidae	Greenshank	طيطوى أخضر الساق	2	-	18	31	1
62	*Tringa ochropus*	Scolopacidae	Green Sandpiper	طيطوى أخضر	1	4	2	3	-
63	*Tringa glareola*	Scolopacidae	Wood Sandpiper	طيطوى الغياض	-	6	17	3	-
64	*Tringa stagnatilis*	Scolopacidae	Marsh Snadpiper	طيطوى المستنقع	-	-	66	3	-
65	*Actitis hypoleucos*	Scolopacidae	Common Sandpiper	طيطوى	-	1	5	6	-
66	*Arenaria interpres interpres*	Scolopacidae	Turnstone	قنبرة الماء	-	-	-	1	-
67	*Larus ichthyaetus*	Laridae	Great Black-headed Gull	نورس السمك	-	-	2	-	-
68	*Larus minutus*	Laridae	Little Gull	نورس صغير	17	3	3894	230	-
69	*Larus ridibundus*	Laridae	Black-Headed Gull	نورس أسود الرأس	36080	25500	13889	2787	1

Table 12.1. cont. 3.

No.	Scientific name	Family	English name	Arabic name	Number				
					78/79	79/80	89/90	94	2000
70	*Larus genei*	Laridae	Slender-Billed Gull	نورس قرقطى	108	6	3	50	131
71	*Larus canus canus*	Laridae	Common Gull	نورس شاع ـ زمج الماء	1	1	-	-	-
72	*Larus fuscus fuscus*	Laridae	Lesser Black-Racked Gull	نورس دغبة ـ جوكة	8	5	2	1	16
73	*Larus argentatus cachinnans*	Laridae	Yellow-Legged Gull	نورس أصفر القدم	21	361	163	132	8
74	*Chlidonias niger niger*	Laridae	Black Tern	خطاف أسود ـ خرشنة	4	-	-	-	-
75	*Chlidonias hybrida hybrida*	Laridae	Whiskered Tern	خطاف أبيض الخد	17382	17500	4503	3893	-
76	*Chlidonias leucoptera*	Laridae	White-winged Black Tern	خطاف أسود الجناح - أبو دفة	-	-	-	-	5220
77	*Sterna albifrons albifrons*[b]	Laridae	Little Tern	خطاف صغير ـ دغبز	4	-	-	-	3427
78	*Sterna hirundo hirundo*	Laridae	Common Tern	خطاف البحر					
79	*Thalasseus sandvicensis sandvicensis*	Laridae	Sandwich Tern	خرشنة	-	-	574	2	-
80	*Streptopelia senegalensis aegyptiaca**	Columbidae	Palm Dove	يمام بلدى	-	-	-	++	42
81	*Streptopelia decaoclo decaoclo*	Columbidae	Coilered Turtle Dove	يمام مطوق	-	-	-	-	4
82	*Centropus senegalensis aegyptius**[b]	Cuculidae	Senegal Coucal	مك ـ كوكو	-	-	-	+	23
83	*Cuculus canorus canorus*	Cuculidae	Cuckoo	هوهو - وقواق	-	-	-	-	2
84	*Tyto alba alba*	Tytonidae	Barn Owl	بوم مصاص ـ أم الصخر	-	-	-	+	-
85	*Athene noctua saharae*	Strigidae	Litlle Owl	أم الصخر	-	-	-	1	-
86	*Athene noctua glaux*	Strigidae	Little Owl	أم قويق	-	-	-	-	3
87	*Alcedo atthis atthis*	Alcedinidae	Kingfisher	صياد السمك ـ رفراف	+	18	36	20	15
88	*Ceryle rudis rudis*[b]	Alcedinidae	Pied Kingfisher	صيد السمك الأبقع ـ كريلا	+	21	333	544	925
89	*Merops orientalis cleopatra*	Meropidae	Little Green Bee-eater	وروار - خضير	-	-	-	-	15
90	*Upupa epops epops*	Upupidae	Hoopoe	هدهد	-	-	-	+	4
91	*Hirundo rustica rustica*	Hirundinidae	Swallow	عصفور الجنة	-	-	-	++	1104

Table 12.1. cont. 4.

No.	Scientific name	Family	English name	Arabic name	Number				
					78/79	79/80	89/90	94	2000
92	*Riparia riparia riparia*	Hirundinidae	Sand Martin	ستوتو	-	-	-	-	50
93	*Calandrella rufescens nicolli**[b]	Alaudidae	Lesser Short Toed Lark	قبرة قصيرة الأصابع صغيرة	-	-	-	+	-
94	*Galerida cristata nigricans**	Alaudidae	Crested Lark	قبرة بشوشة ـ قبرة متوجة	-	-	-	++	4
95	*Anthus cervinus*	Motacillidae	Red-Throated Pipit	بو فصية أحمر الزور	-	-	-	+	-
96	*Motacilla flava pygmaea**	Motacillidae	Egyptian Wagtail	أبو فصادة مصرى	-	-	-	14	-
97	*Motacilla alba alba*	Motacillidae	White Wagtail	أبو فصادة أبيض	-	-	-	+++	-
98	*Motacilla flava flavissima*	Motacillidae	Yellow Wagtail	أبو فصادة أصفر	-	-	-	-	10
99	*Motacilla cinerea cinarea*	Motacillidae	Grey Pied Wagtail	أبو فصادة رمادى	-	-	-	-	6
100	*Lanius collurio collurio*	Laniidae	Red-backed Shrike	دقناش أكحل	-	-	-	-	2
101	*Sturnus vulgaris vulgaris*	Sturnidae	Starling	زرزور	-	-	-	50	-
102	*Corvus corone cornix*	Corvidae	Hooded Crow	قاق ـ غراب بلدى	-	-	-	++	13
103	*Acrocephalus stentoreus stentoreus*[b]	Sylviidae	Clamorous Reed Warbler	هزجة القصب الصيلحة ـ خشنع صيلحة	-	-	-	+++	-
104	*Phylloscorpus collybita collybita*	Sylviidae	Chiffchaff	سكسة ـ شادية الخمايل	-	-	-	+++	-
105	*Prinia gracilis deltae**[b]	Sylviidae	Graceful Warbler	فصية ـ هازجة	-	-	-	+++	-
106	*Scotocerca inquieta inquieta*	Sylviidae	Scrub Warbler	دخلة الدغل – نمنمة الشجر	-	-	-	-	18
107	*Cisticola juncidis juncidis*[b]	Sylviidae	Fan-tailed Warbler	فصية مروحية الذنب	-	-	-	++	-
108	*Saxicola torquata rubicola*	Muscicapidae	Stonechat	قليعى مطوق	-	-	-	4	-
109	*Passer domesticus niloticus*	Passeridae	House Sparrow	عصفور دورى ـ عصفور الغيط	-	-	-	+	-
110	*Passer hispaniolensis hispaniolensis*	Passeridae	Spanish Sparrow	عصفور أسبانى	-	-	-	++	-
111	*Emberiza calandra calandra*	Emberizidae	Corn Bunting	درسة	-	-	-	-	24
112	*Emberiza shoeniclus intermedia*	Emberizidae	Reed Warbler	درسة الغاب	-	-	-	-	4
	Total species				**37**	**41**	**56**	**74**	**53**
	Total individuals ($\times 10^3$)				**311.2**	**245.8**	**94.7**	**20.7**	**13.7**

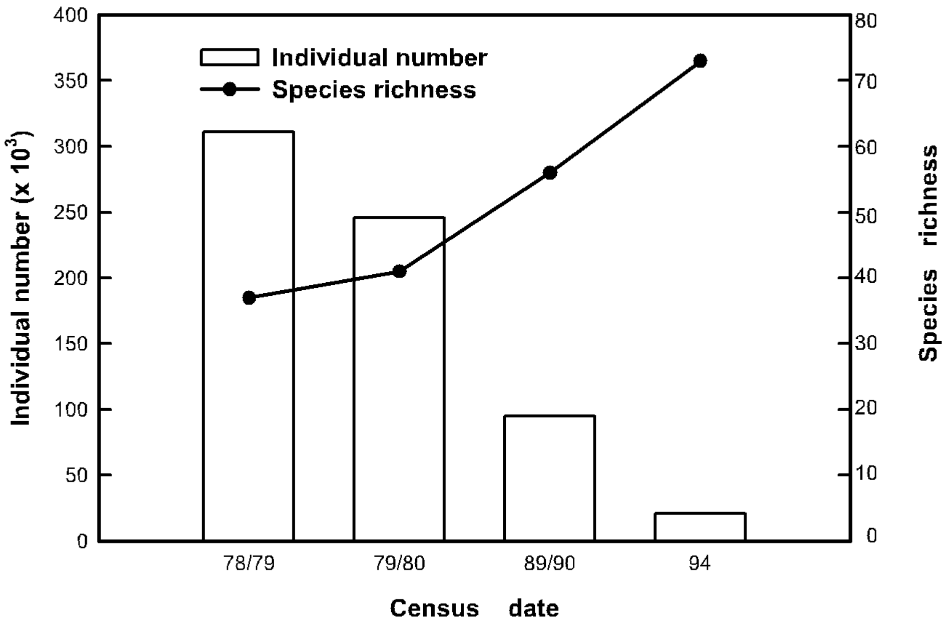


Fig. 12.1. **Relationship between the species richness and individual number during the four winter censuses extended from 1978 to 1994.**

They represent about 47 % of the total endemic avifauna in Egypt (17 species and subspecies as reported by Tharwat 1997).

12.4. ECONOMIC IMPORTANCE

Wall paintings on the old Egyptian temples prove that wildbirds played some economic roles in the ancestors life who utilized them for several purposes such as food, decoration, medicine, education, domestication, sport and religion. At the present time, wildbirds are still being used and several bird species are being trapped allover the Egyptian wetlands and deserts mainly for food and sport. However, assessment of the effect of these activities on the population of the victim captured species and economy was attempted by a few researchers (e.g. Mullie and Meiniger 1983, Goodman *et al.* 1989, and Baha El-Din 1992, 1999).

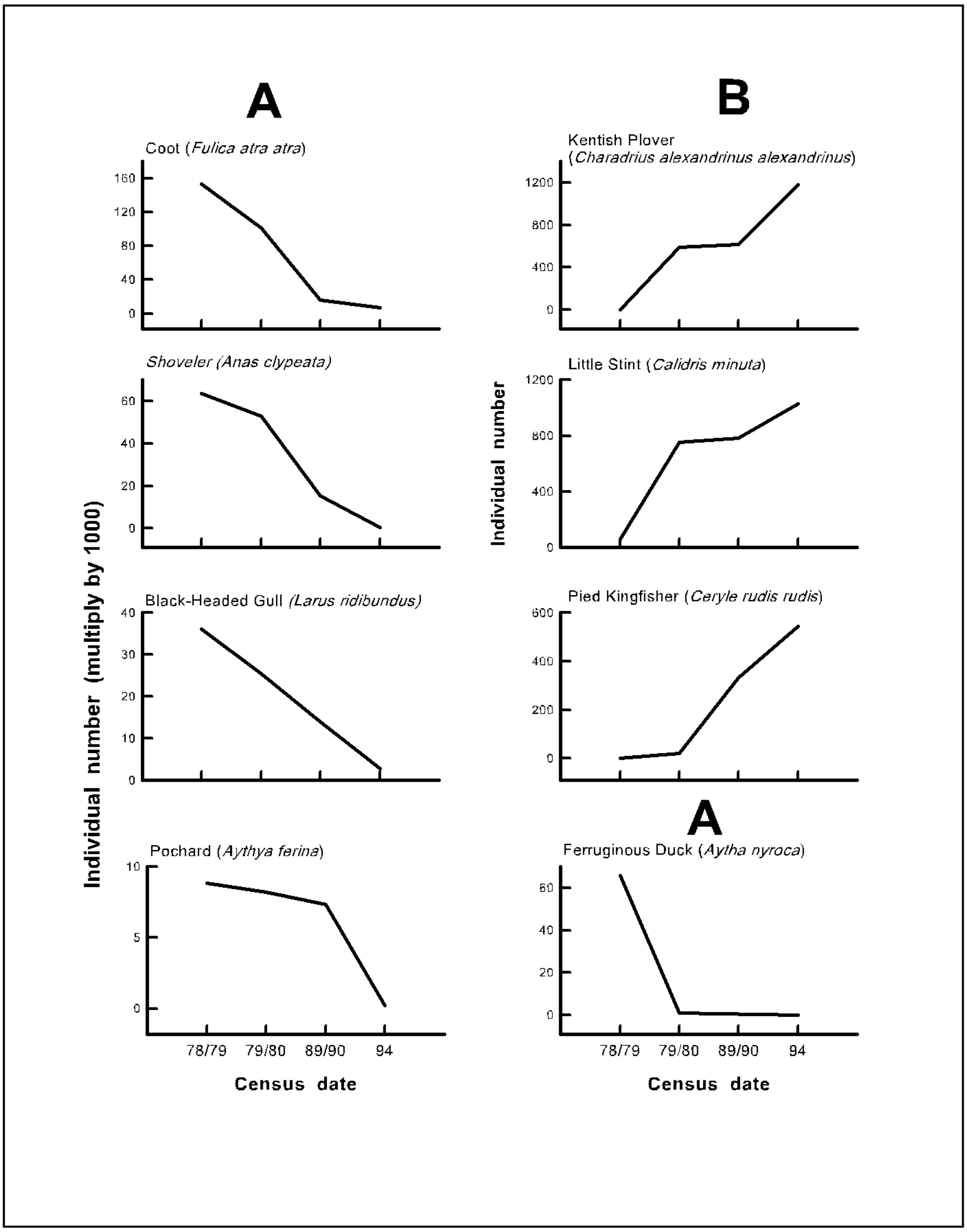


Fig.12.2. **Number of bird individuals in relation to census date. A: decreasing relationship, B: increasing relationship.**

Table 12.2. **Status and abundance of the bird species recorded in Lake Burulus.The abundance categories are R = rare; S = scarce; A = accidental; O = occasional; U = uncommon; C = common, B = abundant (after Goodman *et al.*, 1989, Tharwat 1997). * : Denotes the endemic species, ** : the extinct species, b : breeding species.**

No.	Scientific name	Family	Resident	Visitor		Passer		Total
				Winter	Spring	Summer	Autumn	
1	*Gavia arctica arctica***	Gaviidae						-
2	*Tachybaptus ruficollis ruficollis*[b]	Podicipedidae	C					1
3	*Podiceps cristatus cristatus*	Podicipedidae		C				1
4	*Podiceps nigricollis nigricollis*	Podicipedidae		C				1
5	*Phalacrocorax carbo sinensis*	Phalacrocoracidae		C	R	C	C	4
6	*Ardea cinerea cinerea*	Ardeidae	U	C	S			3
7	*Ardeola ralloides*	Ardeidae	R	S		C	C	4
8	*Nycticorax nycticorax nycticorax*	Ardeidae	R	C		C	C	4
9	*Ixobruchus minutus minutus*[b]	Ardeidae	C	C		C	C	4
10	*Egretta alba alba*	Ardeidae		S		S	S	3
11	*Egretta ibis ibis*	Ardeidae	C	C		C	C	4
12	*Egretta garzetta garzetta*	Ardeidae	S	C		C	C	4
13	*Phoenicopterus ruber roseus*	Phoenicopteridae	S	C				2
14	*Tadorna tadorna*	Anatidae		C				1
15	*Anas platyrhynchos platyrhynchos*	Anatidae	C	C		C	C	4
16	*Anas crecca crecca*	Anatidae		C		C	C	3
17	*Anas strepera strepera*	Anatidae		S		S	S	3
18	*Anas penelope*	Anatidae		C		C	C	3
19	*Anas clypeata*	Anatidae		C		C	C	3
20	*Anas querquedula*	Anatidae				C	C	2
21	*Netta rufina*	Anatidac		S				1
22	*Aythya ferina*	Anatidae		C		C	C	3
23	*Aythya nyroca*	Anatidae		C		C	C	3
24	*Aythya fuligula*	Anatidae		C		C	C	3
25	*Elanus caeruleus caeruleus*	Accipitridae	C					1
26	*Circus cyaneus cyaneus*	Accipitridae		R		R	R	3
27	*Circus aeruginosus aeruginosus*	Accipitridae		S		S	S	3
28	*Circus pygargus*	Accipitridae		O		R	R	3

Table 12.2. cont. 1.

No.	Scientific name	Family	Resident	Visitor		Passer		Total
				Winter	Spring	Summer	Autumn	
29	*Falco tinnunculus tinnunculus*	Falconidae	**C**					**1**
30	*Rallus aquaticus aquaticus*[b]	Rallidae	**C**	**C**				**2**
31	*Porzana porzana*	Rallidae		**S**		**C**	**C**	**3**
32	*Gallinula chloropus chloropus*[b]	Rallidae	**C**	**B**		**B**	**B**	**4**
33	*Prophyrio prophyrio madagascariensis*[b]	Rallidae	**C**					**1**
34	*Fulica atra atra*	Rallidae	**R**	**B**	**R**			**3**
35	*Rostratula benghalensis benghalensis*[b]	Rostratulidae	**C**					**1**
36	*Himantopus himantopus himantopus*	Recurvirostridae	**R**	**R**		**C**	**C**	**4**
37	*Recurvirostra avosetta*	Recurvirostridae	**R**	**C**	**R**			**3**
38	*Glareola pratincola pratincola*[b]	Glareolidae	**C**	**R**		**C**	**C**	**4**
39	*Charadrius hiaticula tundrae*	Charadriidae		**C**	**O**	**C**	**C**	**4**
40	*Charadrius dubius curonicus*	Charadriidae	**R**	**R**		**S**	**S**	**4**
41	*Charadrius pecuarius allenbyi**[b]	Charadriidae	**S**					**1**
42	*Charadrius alexandrinus alexandrinus*[b]	Charadriidae	**C**	**C**		**C**	**C**	**4**
43	*Charadrius leschenaultii*	Charadriidae	**O**	**C**		**C**	**C**	**4**
44	*Pluvialis squatarola*	Charadriidae		**S**	**U**	**C**	**C**	**4**
45	*Vanellus vanellus*	Charadriidae		**C**		**C**	**C**	**3**
46	*Chettusia leucura*	Charadriidae				**R**	**R**	**2**
47	*Hopolopterus spinosus*[b]	Charadriidae	**O**					**1**
48	*Calidris alba*	Scolopacidae		**C**		**C**	**C**	**3**
49	*Calidris temminckii*	Scolopacidae		**R**		**S**	**S**	**3**
50	*Calidris ferruginea*	Scolopacidae		**R**		**S**	**S**	**3**
51	*Calidris minuta*	Scolopacidae		**B**	**U**	**B**	**B**	**4**
52	*Calidris alpina alpina*	Scolopacidae		**B**		**B**	**B**	**3**
53	*Philomachus pugnax*	Scolopacidae		**C**	**R**	**C**	**C**	**4**
54	*Lymnocryptes minimus*	Scolopacidae		**S**		**S**	**S**	**3**
55	*Gallinago gallinago gallinago*	Scolopacidae		**C**		**C**	**C**	**3**
56	*Limosa limosa limosa*	Scolopacidae		**R**	**R**	**C**	**C**	**4**
57	*Limosa lapponica lapponica*	Scolopacidae		**R**		**R**	**R**	**3**
58	*Numenius arquata arquata*	Scolopacidae		**S**	**R**	**S**	**S**	**4**

Table 12.2. cont. 2.

No.	Scientific name	Family	Resident	Visitor		Passer		Total
				Winter	Spring	Summer	Autumn	
59	*Tringa erythropus*	Scolopacidae		**S**		**C**	**C**	**3**
60	*Tringa tetanus totanus*	Scolopacidae		**C**	**O**	**C**	**C**	**4**
61	*Tringa nebularia*	Scolopacidae		**S**	**R**	**C**	**C**	**4**
62	*Tringa ochropus*	Scolopacidae		**S**	**R**	**C**	**C**	**4**
63	*Tringa glareola*	Scolopacidae		**S**	**R**	**C**	**C**	**4**
64	*Tringa stagnatilis*	Scolopacidae		**S**		**S**	**S**	**3**
65	*Actitis hypolecucos*	Scolopacidae		**S**		**C**	**C**	**3**
66	*Arenaria interpres interpres*	Scolopacidae		**S**		**S**	**S**	**3**
67	*Larus ichthyaetus*	Laridae		**R**		**R**	**R**	**3**
68	*Larus minutus*	Laridae		**S**				**1**
69	*Larus ridibundus*	Laridae		**B**	**S**	**B**	**B**	**4**
70	*Larus genei*	Laridae	**S**	**C**	**C**	**C**	**C**	**5**
71	*Larus canus canus*	Laridae		**R**				**1**
72	*Larus foscus foscus*	Laridae		**C**	**R**	**C**	**C**	**4**
73	*Larus argentatus cachinnans*	Laridae	**R**	**C**	**S**			**3**
74	*Chlidonias niger niger*	Laridae		**R**	**R**	**S**	**S**	**4**
75	*Chlidonias hybrida hybrida*	Laridae		**O**	**S**	**C**	**C**	**4**
76	*Chlidonias leucoptera*	Laridae		**C**		**C**	**C**	**3**
77	*Sterna albifrons albifrons*	Laridae	**C**					**1**
78	*Sterna hirundo hirundo*	Laridae			**S**	**C**	**C**	**3**
79	*Thalasseus sandvicensis sandvicensis*	Laridae		**C**	**S**	**C**	**C**	**4**
80	*Streptopelia senegalensis aegyptiaca**	Columbidae	**B**					**1**
81	*Streptopelia decaoclo decaoclo*	Columbidae	**C**					**4**
82	*Centropus senegalensis aegyptlus**[b]	Cuculidae	**C**					**1**
83	*Cuculus canorus canorus*	Cuculidae				**S**	**S**	**2**
84	*Tyto alba alba*	Tytonidae	**C**					**1**
85	*Athene noctua saharae*	Strigidae	**C**					**1**
86	*Athene noctua glaux*	Strigidae	**C**					**1**
87	*Alcedo atthis atthis*	Alcedinidae	**O**	**C**		**C**	**C**	**4**
88	*Ceryle rudis rudis*[b]	Alcedinidae	**C**					**1**

Table 12.2. cont. 3.

No.	Scientific name	Family	Resident	Visitor		Passer		Total
				Winter	Spring	Summer	Autumn	
89	*Merops orientalis cleopatra*	Meropidae	**C**					**1**
90	*Upupa epops epops*	Upupidae	**C**			**C**	**C**	**3**
91	*Hirundo rustica rustica*	Hirundinidae		**R**		**C**	**C**	**3**
92	*Riparia riparia riparia*	Hirundinidae		**S**		**B**	**B**	**3**
93	*Calandrella rufescens nicolli**[b]	Alaudidae	**C**					**1**
94	*Galerida cristata nigricans**	Aludidae	**B**					**1**
95	*Anthus cervinus*	Motacillidae		**B**		**B**	**B**	**3**
96	*Motacilla flava pygmaea**	Motacillidae	**C**					**1**
97	*Motacilla alba alba*	Motacillidae		**B**		**B**	**B**	**3**
98	*Sturnus vulgaris vulgaris*	Sturnidae		**C**				**1**
99	*Motacilla flava flavissima*	Motacillidae		**UC**		**C**	**C**	**3**
100	*Motacilla cinerea cinarea*	Motacillidae		**C**		**C**	**C**	**3**
101	*Lanius collurio collurio*	Laniidae		**I**		**C**	**C**	**2**
102	*Corvus corone cornix*	Corvidae	**C**					**1**
103	*Acrocephalus stentoreus stentoreus*[b]	Sylviidae	**B**					**1**
104	*Phylloscopus collybita collybita*	Sylviidae				**B**	**B**	**2**
105	*Prinia gracilis deltae**[b]	Sylviidae	**B**					**1**
106	*Scotocerca inquieta inquieta*	Sylviidae	**C**					**1**
107	*Cisticola juncidis juncidis*[b]	Sylviidae	**B**					**1**
108	*Saxicola torquata rubicola*	Muscicapidae		**C**		**C**	**C**	**3**
109	*Passer domesticus niloticus*	Passeridae	**B**					**1**
110	*Passer hispaniolensis hispaniolensis*	Passeridae		**B**	**O**	**B**	**B**	**4**
111	*Emberiza calandra calandra*	Emberizidae		**C**		**C**	**C**	**3**
112	*Emberiza shoeniclus intermedia*	Emberizidae		**A**				**1**
Total			**46**	**80**	**23**	**72**	**72**	**112**

Table 12.3. **National and world distribution of the bird species recorded in Lake Burullus (after Goodman *et* al. 1989, Tharwat 1997). * Denotes the endemic species, ** the extinct species, b ; breeding species.**

No.	Scientific name	World distribution	National distributiom
1	*Gavia arctica arctica***	N. America, N. Asia N. Europe.	N. Coast and lakes.
2	*Tachybaptus ruficollis ruficollis*[b]	Europe, Asia, Africa.	Nile Valley and Delta, W. Desert Oases.
3	*Podiceps cristatus cristatus*	Parts of Europe, Asia, Africa, Australia	Nile Valley and Delta, Suez Canal, Aqaba Gulf.
4	*Podiceps nigricollis nigricollis*	Atlantic Coasts, Medet. Region, Arabic Gulf.	Nile Delta and Valley, Suez Canal, Lake Bardaweel, other Coastal Waters.
5	*Phalacrocorax carbo sinensis*	Europe, C. and S. Asia, Africa, Australia and E.N. America.	Nile Delta and Valley, Red Sea, Medit. Sea.
6	*Ardea cinerea cinerea*	Europe, Asia, Parts of Africa.	Nile Delta and Valley, Red and Medit. Seas.
7	*Ardeola ralloides*	S. Europe, S.E. Asia, Africa.	Bilbais, Aswan, Damietta
8	*Nycticorax nycticorax nycticorax*	C. and S. Europe, S. Asia, Africa	Bilbais, Aswan
9	*Ixobruchus minutus minutus*[b]	Europe, Asia, Africa, Australia.	Nile Delta and Valley.
10	*Egretta alba alba*	S. Europe, N. Asia, N. Africa, India.	Nile Delta and Valley.
11	*Egretta ibis ibis*	Spain to Iran, N. and C. Africa, E.N. and N.S. America.	Nile Delta and Valley.
12	*Egretta garzetta garzetta*	Parts of Europe, S. Asia, Africa, Australia.	Nile Delta and Valley, Medit. Coast.
13	*Phoenicopterus ruber roseus*	Africa, S.W. Asia, C. America, S. Europe.	Lake Mallaha, Lake Bardaweel, Lake Qaruun
14	*Tadorna tadorna*	Europe, Asia.	Medit. Sea, N. Red Sea.
15	*Anas platyrhynchos platyrhynchos*	Europe, Asia, N.W. Africa, N. America.	Nile Delta and Valley.
16	*Anas crecca crecca*	Europe, Asia, Africa, N. America.	Nile Delta and Valley.
17	*Anas strepera strepera*	N. Hemisphere throughout, to China and Japan, to the W. Indies, Mexico, Florida.	Nile Delta and Valley.
18	*Anas penelope*	Europe, Asia, Africa, N. America.	Nile Delta and Valley.
19	*Anas clypeata*	Medit. Basin, W. Morocco, E. Africa, Iran, Iraqi.	Nile Delta and Valley.
20	*Anas querquedula*	Europe, Asia, Africa	Mediterranean, Red Sea.
21	*Netta rufina*	Europe, Turkey, Near East., Iraq, Marocco, Algeria, E. and C. Arabia, Tunisia, Libya.	Nile Delta and Valley.
22	*Aythya ferina*	Europe and Asia.	Nile Delta and Valley.

Table 12. 3. Cont. 1.

No.	Scientific name	World distribution	National distributiom
23	*Aythya nyroca*	Europe and Asia to Lake Baikal, in non-breeding season to Cape Verde Islands, Iran, N Africa, Sudan, S. Arabia, India, China.	Nile Delta and Valley.
24	*Aythya fuligula*	Europe, Asia, Africa.	Nile Delta and Valley.
25	*Elanus caeruleus caeruleus*	Africa, S. Asia.	Nile Delta and Valley.
26	*Circus cyaneus cyaneus*	Europe, Asia, N. Africa.	Nile Delta.
27	*Circus aeruginosus aeruginosus*	Europe, Asia, Africa.	Nile Delta and Valley.
28	*Circus pygargus*	W. Europe, E. C. Asia, China	Wide spread
29	*Falco tinnunculus tinnunculus*	Europe, to N.E. Asia C. Africa, India.	Nile Delta and Valley, Sinai, N. Coast.
30	*Rallus aquaticus aquaticus*[b]	W. Europe to W. Siberia, N.E. Africa.	N. Egypt.
31	*Porzana porzana*	W. Europe, N. Africa to C. Asia, India.	Sinai, S. Nile Valley, Wadi El-Natruun, W. Desert
32	*Gallinula chloropus chloropus*[b]	Europe, N. Africa, Middle East., Russia.	Nile Delta and Valley, Suez Canal, Faiyuum.
33	*Prophyrio prophyrio madagascariensis*[b]	E. and S. Africa, Madagascar.	Nile Delta and Valley, Suez Canal, Wadi El-Rayan, Wadi El-Natruun.
34	*Fulica atra atra*	Europe to S. Asia, N. Africa.	Nile Delta Lakes, Lake Qaruun.
35	*Rostratula benghalensis benghalensis*[b]	Africa, S. Asia to Java, Philippine Islands.	Nile Delta and Valley, Wadi El-Natruun, Faiyuum, Suez.
36	*Himantopus himantopus himantopus*	S. Europe to China, India, C. Africa.	Wadi El-Natruun, Faiyuum, N. Nile Delta
37	*Recurvirostra avosetta*	Europe to China, India, S. Africa.	Wadi El-Natruun, Faiyuum, Delta Lakes.
38	*Glareola pratincola pratincola*[b]	Medit. to N.W. India India, N. Africa.	Nile Delta, W. N. Coast
39	*Charadrius hiaticula tundrae*	N. Europe, N. Asia, Iran, E. Africa.	W. Desert, Nile Delta and Valley, Red Sea.
40	*Charadrius dubius curonicus*	Europe, N. Asia, S. Africa, India, China.	Wadi El-Natruun, W. Oases, N. Coast, Nile Delta and Valley, Red Sea, Sinai.
41	*Charadrius pecuarius allenbyi**[b]	Endemic.	Wadi El-Natruun, Nile Delta, Suez Canal, Faiyuum, Lake Nasser.
42	*Charadrius alexandrinus alexandrinus*[b]	E. Asia, Red Sea, S. Africa, Australia.	Medit. and Red Seas Coasts.
43	*Charadrius leschenaultii*	C. Asia, India, Malaysia, E. Africa.	Red Sea.
44	*Pluvialis squatarola*	Circumpolar, Africa, Australia, S. America, Europe	N. Egypt, Red Sea.
45	*Vanellus vanellus*	W. Europe to China, Japan.	N. Egypt.
46	*Chettusia leucura*	W. and C. Asia, N.E. Africa, N.W. India.	E. Egypt.
47	*Hopolopterus spinosus*[b]	Middle East, C. and E. Africa.	Wadi El-Natruun, Nile Delta and Valley, Suez Canal, Faiyuum, Sinai, Wadi El-Rayan

Table 12.3. Cont. 2.

No.	Scientific name	World distribution	National distributiom
48	*Calidris alba*	N. Holarctic, S. America, India, Australia.	Medit. and Red Sea Coasts, Inland Waters.
49	*Calidris temminckii*	N. Europe, N. Asia, N.E. Africa to China.	Deversoir, Red Sea Coast.
50	*Calidris ferruginea*	N. Asia to Europe, Africa, India, Australia.	Medit. Coast, Nile Delta, Lake Qaruun, Suez.
51	*Calidris minuta*	N. Europe, S. Africa, W. India.	N. lakes
52	*Calidris alpina alpina*	N. Europe, N.W. Asia, S.W. Asia, N.E. Africa.	Faiyuum, Nile Delta lakes, Red Sea Coast, W. Desert
53	*Philomachus pugnax*	N. Europe, Asia, Africa, India, Burma	Nile Delta and Valley
54	*Lymnocryptes minimus*	N. Europe, W. Asia, N. Africa, Iran, India	W. desert, Oases, Nile Delta, Suez Canal, Faiyuum, N. Sinai.
55	*Gallinago gallinago gallinago*	N. Palaearctic, E. Africa, India, China.	W. Desert Oases, Nile Delta and Valley, Suez Canal, Faiyuum.
56	*Limosa limosa limosa*	Europe, W. Asia, N. Africa, India.	N. Sinai, Wadi El-Natruun, Faiyuum, Nile Delta, Red Sea
57	*Limosa lapponica lapponica*	N. Europe, N. Asia, Tropical Africa, N. India	Mediterranean and Red Sea coasts
58	*Numenius arquata arquata*	N. Europe, Russia, Africa, N.W. India.	Coastal Areas, Inland lakes, Red Sea Coast.
59	*Tringa erythropus*	N. Europe, N. Russia, Africa, China.	Lake Maryut, W. Desert Oases, Red Sea Coast, Nile Delta and Valley.
60	*Tringa totanus totanus*	N. Europe, W. Siberia, Africa, W. Asia.	Lake Manzala, Suez Bay, W. Desert and Nile Valley.
61	*Tringa nebularia*	N. Palaearctic, Africa, India to New Zealand.	W. Desert Oases, Nile Delta and Valley, Red Sea Coast.
62	*Tringa ochropus*	N. Palaearctic, C. Africa to Philippine Islands.	N. Coast of Sinai, Bahariya Oasis.
63	*Tringa glareola*	N. Palaearctic, Africa, S.E. Asia, Australia.	W. Desert, Red Sea Coast, Mountains of S. Sinai
64	*Tringa stagnatilis*	S. Europe to Mangolia, Africa, Australia	W. Desert Oases, Nile Valley, Red Sea Coast
65	*Actitis hypolecucos*	Palaearctic, Africa, N.E. Asia to Australia.	Nile Delta and Valley, W. Desert Oases, Red Sea Coast
66	*Arenaria interpres interpres*	N. Palaearctic, Africa, S.E. Asia, Australia.	Medit.and Red Sea Coasts, Suez Canal.
67	*Larus ichthyaetus*	S. Russia, Mongolia to Red Sea, India.	Red Sea Coast, Nile Delta and Valley.
68	*Larus minutus*	N. Europe, Siberia to Medit., Black Sea.	Medit. and Coast, Nile Delta and Valley, Red Sea, S.

Table 12.3. Cont. 3.

No.	Scientific name	World distribution	National distributiom
			Sinai
69	*Larus ridibundus*	Europe, Asia to N. Africa, India, Philippine Islands.	Nile Delta and Valley, Red Sea Coast, Lake Qaruun, Lake Nasser
70	*Larus genei*	Medit. Sea, Black Sea, Asia Minor.	N.W. Sinai, Lake Qaruun, Medit. and Red Seas.
71	*Larus canus canus*	N.W. Europe to Medit.	N. Egypt, mainly Nile Delta, Red Sea.
72	*Larus foscus foscus*	Scandinavia to W. and E. Africa.	Nile Valley, Suez Canal, Red Sea, N. Sinai, Wadi El-Natruun, Lake Qaruun.
73	*Larus argentatus cachinnans*	S. Russia, S.C. Asia, N. Red Sea	W. Medit. Coast
74	*Chlidonias niger niger*	Europe, W. Asia, S.C. Africa.	Wadi El-Natruun, N. Sinai, Nile Delta and Valley, Red Sea.
75	*Chlidonias hybrida hybrida*	S. Europe, S.W. Asia, E. and W. Africa.	Nile Delta
76	*Chlidonias leucoptera*	Europe, W. Asia, S. C. Africa	Wadi En-Natruun, N. Sinai coast, Nile Delta and Valley, red Sea coast.
77	*Sterna albifrons albifrons*[b]	Europe, W. Asia, N. Africa, N.E. India.	Medit. and Red Sea Coasts, Faiyuum.
78	*Sterna hirundo hirundo*	N. America, Europe, W. Asia, S. America, W. Africa	Mediterranean and Red Sea coasts, Nile Valley, Suez Gulf.
79	*Thalasseus sandvicensis sandvicensis*	W.S. Europe, Africa, N.W. India.	Coasts of Medit, Red Seas.
80	*Streptopelia senegalensis aegyptiaca**	Endemic.	Nile Delta and Valley, E. and W.E. Deserts.
81	*Centropus senegalensis aegyptIus**[b]	Endemic.	Nile Delta and Valley, Faiyuum, Suez Canal.
82	*Streptopelia decaoclo decaoclo*	Europe to W. China	Wadi En-Natruun, Nile Delta, N. Nile Valley, Sucz Canal, Sinai
83	*Cuculus canorus canorus*	Europe, W. Siberia, E. and S. Africa	Western Desert, Eastern Desert, Sinai
84	*Tyto alba alba*	W. Europe.	Wadi El-Natruun, Nile Delta and Valley, Sinai.
85	*Athene noctua saharae*	S. Morocco to N. Saudi Arabia.	W. and E. Desert, Sinai, Nile Delta and Valley.
86	*Athene noctua glaux*	N. Africa	N. Coast, Nile Delta and Valley
87	*Alcedo atthis atthis*	Medit., Syria, Arabia.	N. Coast, W. Desert, Nile Delta and Valley, Suez Canal.
88	*Ceryle rudis rudis*[b]	Asia Minor, Iran, Africa.	Nile Delta and Valley, Faiyuum.
89	*Merops orientalis cleopatra*	Endemic	Nile Delta and Valley, Faiyuum
90	*Upupa epops epops*	Europe, W. Asia to W. and C. Africal, India.	Nile Delta and Valley, W. Oases, N. Sinai, Suez Canal.
91	*Hirundo rustica rustica*	Europe, W. Asia, Africa, India.	Desert Oases, Nile W. Delta and Valley, S. Sinai
92	*Riparia riparia riparia*	N. America, N. S. America, Europe, Asia, N. and N.E. Africa	Desert areas, Nile Delta and Valley

Table 12.3. Cont. 4.

No.	Scientific name	World distribution	National distributiom
93	*Calandrella rufescens nicolli**[b]	Endemic	Nile Delta and Salt Marshes
94	*Galerida cristata nigricans**	Endemic	Nile Valley and Delta, Faiyuum, Lake Nasser, Sinai
95	*Anthus cervinus*	E. Europe, E. Asia, W. and E. Africa, India	N. Coast, N. Lakes
96	*Motacilla flava pygmaea**	Endemic	Wadi El-Natruun, Nile Delta and Valley, Faiyuum, Suez Canal
97	*Motacilla alba alba*	Europe, Russia, N. and E. Africa, Iran, Arabia.	Nile Delta and Valley, E. Desert, N. Coast
98	*Motacilla flava flavissima*	Northwest Europe, Spain, N. Africa	S. Sinai, Gabal Elba, Gabal Uweinat, Suez Canal, Upper Egypt.
99	*Motacilla cinerea cinarea*	Europe, N. Africa, Iran, India, C. S. Africa	N. Sinai coast, N. coast, W. desert, Nile Delta and Valley, Suez Canal, Faiyuum.
100	*Lanius collurio collurio*	Europe, Siberia, W. Asia, S. Africa	N. coast, W. Desert, W. Nile Delta
101	*Sturnus vulgaris vulgaris*	N. C. Europe.	N. Coast, Nile Delta, Suez Canal.
102	*Corvus corone cornix*	N. E. Europe.	Nile Delta and Valley, Suez Canal, Fayiuum, N.E. Sinai
103	*Acrocephalus stentoreus stentoreus*[b]	Palestine, Iraq, Iran, Oman, Arabia	Nile Delta and Valley, Suez Canal, Faiyuum, Wadi El-Rayan, W. Desert Oases
104	*Phylloscopus collybita collybita*	W. and S. Europe, N. Africa.	Red Sea Coast, Gabal Elba.
105	*Prinia gracilis deltae**[b]	Endemic.	Delta Lakes, N. Coast, W. Desert, Nile Valley, Faiyuum, Suez Canal, Sinai.
106	*Scotocerca inquieta inquieta*	N. Arabia	N-E Desert, S. Sinai
107	*Cisticola juncidis juncidis*[b]	S. Europe, Asia Minor, Egypt.	Nile Delta
108	*Saxicola torquata rubicola*	W. Europe, N. Africa, Middle East.	Nile Delta and Valley, Suez Canal Area, Faiyuum, Wadi El-Natruun, E. Sinai.
109	*Passer domesticus niloticus*	N.E. Africa.	N. Coast, W. Desert, Nile Delta and Valley, Red Sea Coast, Sinai.
110	*Passer hispaniolensis hispaniolensis*	S.W. Europe, N. Africa Asia Minor.	N. Coast, Nile Delta and Valley, Faiyuum, Suez Canal and Sinai
111	*Emberiza calandra calandra*	Europe to Sinkiang, S. Iran	Nile Delta and Valley, N. Sinai, Suez Canal, Faiyuum
112	*Emberiza shoeniclus intermedia*	N-W Europe, C. Russia, Turkey, N. Africa	Salluum, Sinai

12.4.1. Waterfowl Hunting

Waterfowl hunting is an old activity in Egypt that goes back to the dynastic time. At present, waterfowl are still being hunted allover the Egyptian wetlands especially Lake Burullus. Two types of waterfowl hunting are known in Egypt: commercial hunting and sport hunting, both are practiced mainly during the winter season when there is abundance in the number of wintering birds.

12.4.1.1. Commercial hunting

The commercial hunting occurs by trapping and shooting waterfowl by the local inhabitants living around the lake who are mostly fishermen. The catch is sold alive or dead in markets in Port Said and Damietta, some smaller bird markets are distributed in villages around the lake. It was estimated that the total annual catch of waterbirds from Lake Burullus ranged from 28000 to 57600 birds. The overall estimate of the annual number of waterbirds is about half a million birds which brings a modest economic value to the national income (Goodman *et al.* 1989).

Historically, Quail netting is an old activity in Egypt that dates back to the Old Kingdom (2325 BC) as depicted on the tombs of Mereruka at Saqqara (Houlihan and Goodman 1986). At the beginning of this century, millions of Quails were exported from Egypt to Europe. Between 1906 and 1913 the number of Quails exported ranged from one to two millions. In 1919 the estimated figure was 3/4 million, and in 1925 and 1926 about half a million were exported to Europe. Since the 1920's and 1930's the number of Quail netted along the north coast have declined, consequently there was no more export (see Goodman *et al.* 1989).

12.4.1.2. Sport hunting

Sport hunting is a non commercial hunting occurs mainly for pleasure, and the hunted birds are consumed by the hunter's families and friends. This type of hunting is well organized by two shooting clubs based in Cairo and Alexandria. The Cairo Shooting Club hires a number of lakes from Governorates of Sharkia and Ismaelia and maintains them to be used in the winter season as hunting reserves. Duck shooting at these reserves is allowed only on 16 days per year (one day every week), lasting from early December to Mid March. The total number of ducks shot at the hunting reserves of Egyptian Shooting Clubs was estimated to be between 20000 to 30000 per season (Mullie and Meininger 1983). The economic value of hunting by the shooting club is related to the fees of hiring the lakes from the Governorates and to few individuals employed by the shooting clubs to guard the hunting reserves. However, this economic value cannot be considered of significant weight. Furthermore, there are several thousands of sport hunters, who are not members

of shooting clubs, they hunt waterfowl allover the Delta and western desert lakes. Their annual bag is estimated to be 3000 – 4500 birds (Goodman *et al.* 1989). There is no economic value for this type of hunting, apart of the free meals it provides for several thousands of people. However, most of the hunters are not dependent on these meals and the hunting occurs mainly for recreation.

12.4.2. Capturing of Birds of Prey

It is certain that the capture and trade of birds of prey (other than large falcon) is the most destructive and least economically justifiable bird catching activity practiced in the Egyptian wetlands. There are also relatively few key trade outlets through which the birds reach the market, which might be relatively easy to ban the birds off the market. A first step in this action area is to change law no. 53 for 1966, which provides protection for all birds beneficial to agriculture, including birds of prey (according to Ministerial Decree 66 for 1983). This law protects birds of prey from being captured and killed, but no where does it prohibit the trade in these birds. Thus, it is currently not possible to make any legal action concerning birds offered for sale on the market (Tharwat and Hamied 2000).

It is probably unpractical to attempt banning the capture of birds of prey completely, but it might be feasible to regulate this practice, allowing the catchers to capture a certain number of large falcons every year, and prohibit completely the capture and trade of all other birds of prey. Certain catching methods which involve the use of other birds of prey as decoys should also be banned.

12.5. MANAGEMENT PRACTICES

Tharwat and Hamied (2000) suggested the following management practices in Lake Burtullus: 1- establish a training program to train people in bird watching, identification of birds, ringing, counting and photography; 2- support the Burullus Protectorate area with the instruments that help in the recording and identification of the bird during their movements; 3- strengthen the law enforcement in the protected area; 4- carrying out public awareness programs to inform people about the importance of protected areas and wildlife; 5- encourage the activity of bird watchers and find the best way to attract them; 6- publish a quarterly newsletter and a field guide for the avifauna of the area; 7- establish a page in the Internet about the avifauna of the area; 8- hold an international conference every three years to discuss the status of the avifauna of the area and compare it with the world status; 9- encourage the study of birds as pests for agriculture and aquaculture in Egypt; 10- extend the study of the avifauna to be done throughout the year seasons; 11- there is a great need for action to prevent habitat manipulation that occurs in the protected areas which

leads to damage the avifauna; 12- there must be a study of environmental impact assessment for any project or activity in or around the protected area; 13- prevention of Quail netting inside the protected area; 14- establish a program supported by donors or international agencies for protecting the threatened bird species; and 15- encourage local organizations and NGO's to participate and play their role in the conservation of the area.

12.6. SUGGESTED FUTURE STUDIES

Concurrent research by the Ministry of Water Resources and Irrigation has revealed that little loss of mud flat area will occur over the next hundred years as a result of sea level rise (Tharwat and Hamied 2000). A similar, fairly inexact estimate of the change of habitat as a result of climate change means that we are at present only able to draw general conclusions. We can for instance, conclude that the Oystercatcher numbers will decline due to the effect of climate change on the loss of both summer and winter habitats. For the time being therefore, we are not able to make exact predictions about the consequences of climate change on the numbers of wading birds (Ens 1996). According to this, there is a great need to study correlation between the physical factors and bird migration. Also, there is a need to study the correlation between the physical factors in the breeding area of migratory birds, the migration timing and the behaviour of migratory birds during migration.

12.7. SUMMARY

The bird surveys in Lake Burullus indicated the presence of 112 species and subspecies, which constitute about 22% of the total Egyptian avifauna. During four winter surveys (1978, 1979, 1989, 1994), there was a remarkable increase in species richness associated with a sharp decrease in the density of some populations. The sharp density decreasing was quite clear in case of Coot, Shoveler, Black headed gull, Pochard and Ferruginus Duck. On the other hand, some other populations such as Kingfish Plover, Little Stint and Pied Kingfisher had an obvious increasing density.

Of the 112 birds recorded in Lake Burullus, 46 are residents, 80 are winter visitors, 23 are spring visitors and 72 are both summer and autumn passers. The collection of information about the national and world distributions of these birds indicated the possibility of occurrence of 8 endemic species and subspecies, which represent about 47% of the total endemic avifauna in Egypt.

Waterfowls are still being hunted allover the Egyptian wetlands, particularly Lake Burullus. This includes two types of hunting, commercial and sport hunting, both are practiced mainly during winter season where there is an abundance of wintering birds. The capturing of birds of prey, which practiced in

the protected area, is the most destructive and less economically justifiable bird catching activity.

Many management practices are suggested to conserve the bird populations in Lake Burullus such as law enforcement in the protected area, carrying out public awareness programs about the importance of wildlife conservation in general, and that of avifauna in particular, encourage the activity of bird watching via ecotourism, preventing of habitat destruction or modification, establishing a program for protecting the threatened bird species and encourage the local organizations and NGO's to participate in the management of the protected area.

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12.9. PLATES OF BIRDS: 12.1 – 12.22
(After Porter & Cottridge 2001)

Plate 12.1
Tachybaptus ruficollis ruficollis
Podiceps cristatus cristatus
Egretta alba alba
Phalacrocorax carbo sinensis

Plate 12.2
Ardea cinerea cinerea
Podiceps nigricollis nigricollis
Ardeola ralloides

Plate 12.3
Nycticorax nycticorax nycticorax
Ixobruchus minutus minutus

Plate 12.4
Phoenicopterus ruber roseus
Egretta garzetta garzetta
Anas penelope

Plate 12.5
Anas clypeata
Anas querquedula
Aytha nyroca
Elanus caeruleus caeruleus

Plate 12.6
Netta rufina
Circus aeruginosus aeruginosus
Porzana porzana

Plate 12.7
Porphyrio porphyrio madagascariensis
Fulica atra atra
Rostratula benghalensis benghalensis
Himantopus himntopus himntopus

Plate 12.8
Recurvirostra avosetta
Glareola pratincola pratincola
Charadrius hiaticola tundrae
Charadrius dubius curonicus

Plate 12.9
Charadrius pecuarius allenbyi
Charadrius alexandrinus alexandrinus
Charadrius leschenaultii
Pluvialis squatarola

Plate 12.10
Vanellus vanellus
Calidris ferruginea
Hoplopterus spinosus

Plate 12.11
Calidris minuta
Philomachus pugnax
Gallinago galinago galinago
Limosa limosa limosa

Plate 12.12
Tringa glareola
Actitis hypoleucos
Tringa stagnatilis
Larus ichthyaetus

Plate 12.13
Larus minutus
Larus ridibundus
Larus genei
Larus fuscus fuscus

Plate 12.14
Chlidonias hybrida hybrida
Chlidonias leucoptera
Sterna albifrons albifrons
Streptopelia senegalensis aegyptiaca

Plate 12.15
Centropus senegalensis aegyptius
Cuculus canorus canorus
Ceryle rudis rudis
Streptopelia decaoclo decaoclo

Plate 12.16
Tyto alba alba
Athene noctua saharae

Plate 12.17
Athene noctua glaux
Alcedo atthis atthis

Plate 12.18
Upupa epops epops
Hirundo rustica rustica
Riparia riparia riparia
Merops orientalis cleopatra

Plate 12.19
Anthus cervinus
Motacilla alba alba
Motacilla flava flavissima

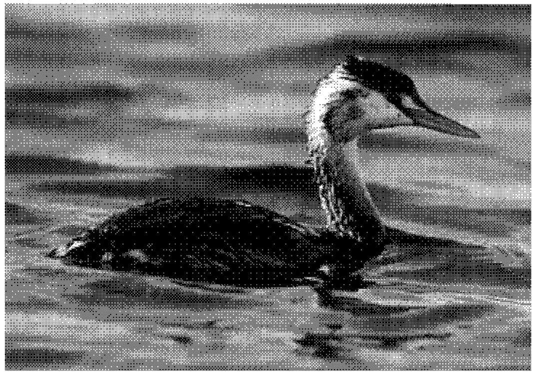
Plate 12.20
Corvus corone cornix
Sturnus vulgaris vulgaris
Acrocephalus stentoreus stentoreus

Plate 12.21
Phylloscorpus collybita collybita
Scotocerca inquieta inquieta
Cisticola juncidi juncidis
Passer domesticus niloticus

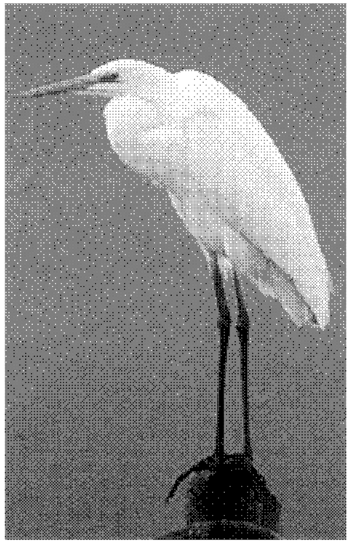
Plate 12.22
Saxicola torquata rubicola
Emberiza shoeniclus intermedia
Passer hispaniolensis hispaniolensis

Plate 12.1

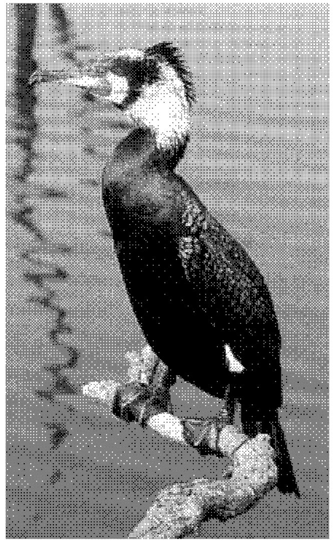
Tachybaptus ruficollis ruficollis زهوت



Podiceps cristatus cristatus غطاس متوج

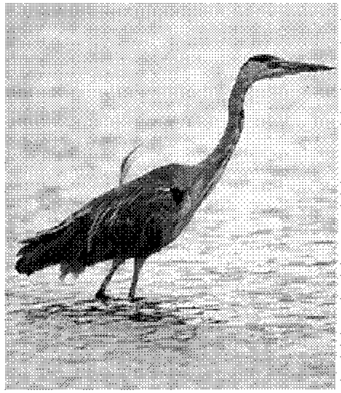


Egretta alba alba
بلشون أبيض كبير

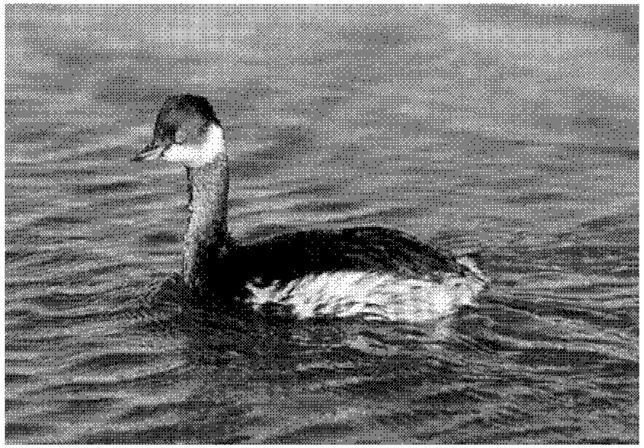


Phalacrocorax carbo sinensis
غراب البحر – أبو غطاس

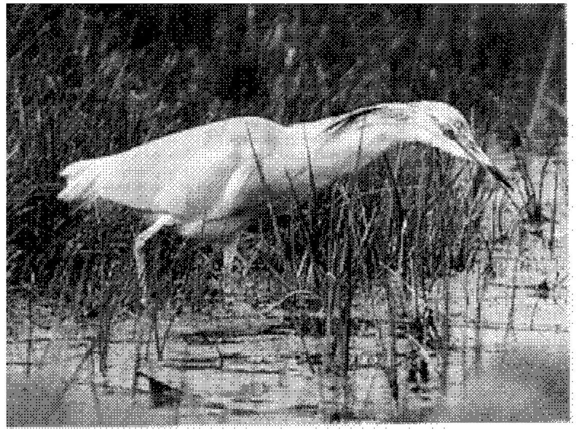
Plate 12.2

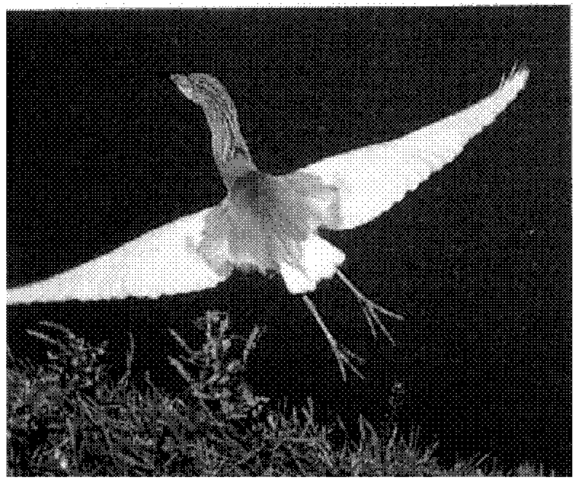


Ardea cinerea cinerea بلشون رمادى



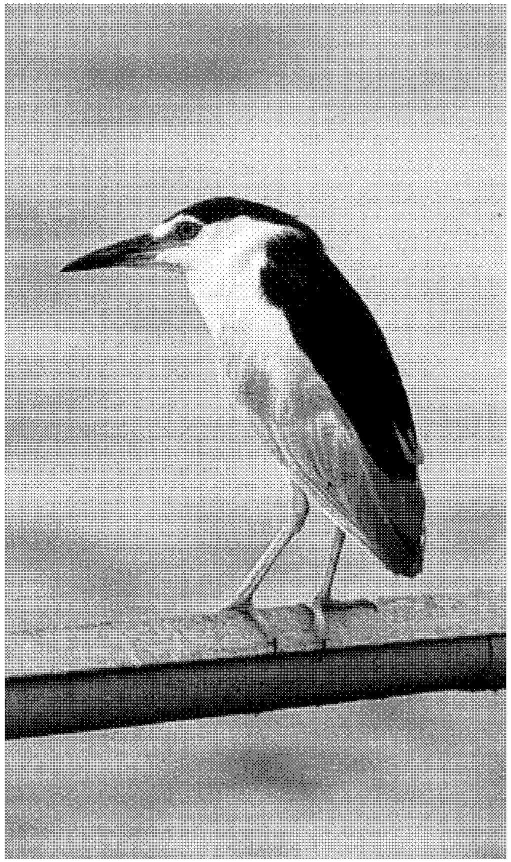
غطاس أسود الرقبة *Podiceps nigricollis nigricollis*



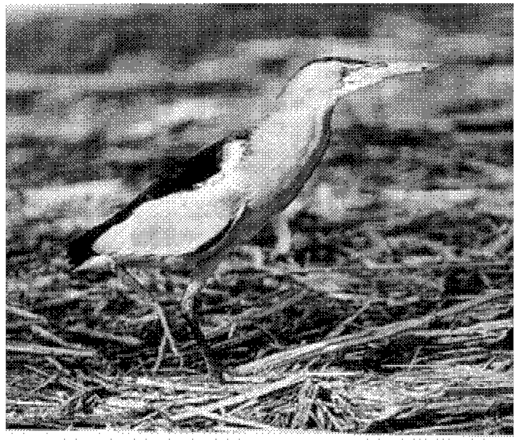


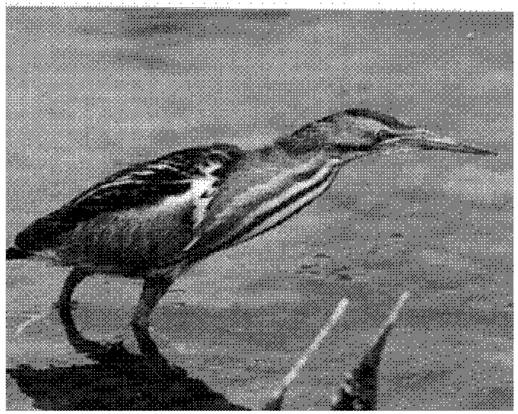
Ardeola ralloides واق أبيض

Plate 12.3



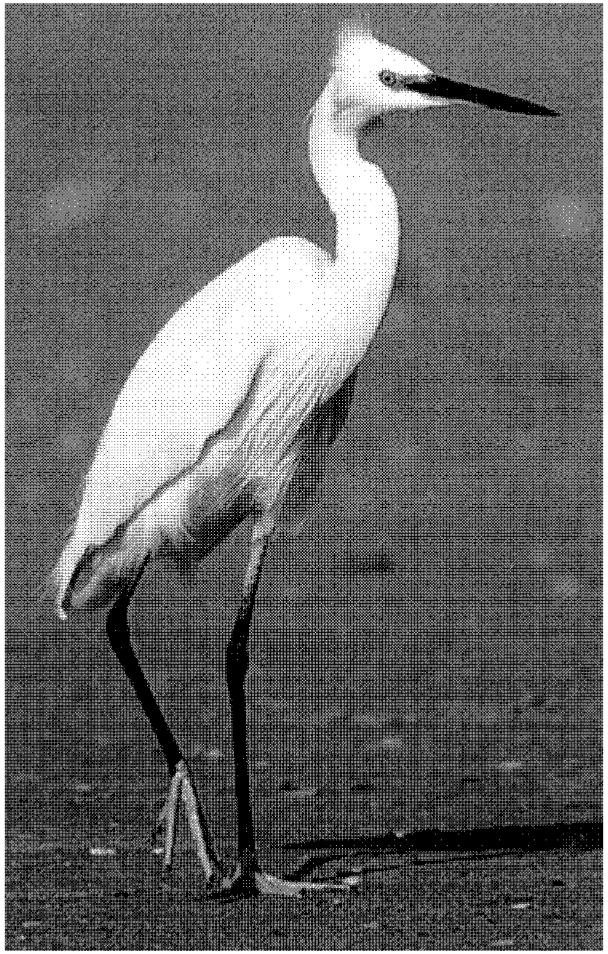
Nycticorax nycticorax nycticorax
غراب الليل – واق الشجر



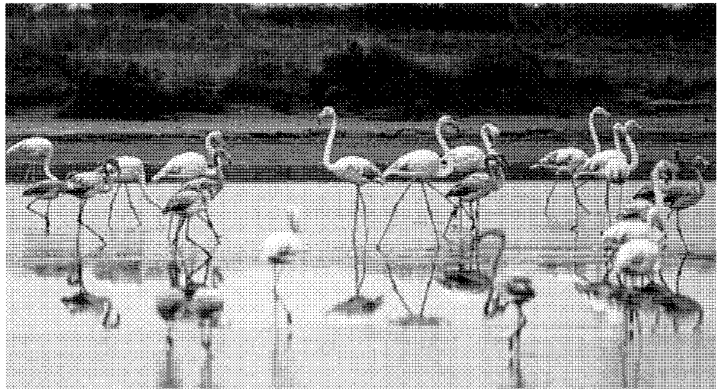


Ixobruchus minutus minutus
واق صغير - مليحة

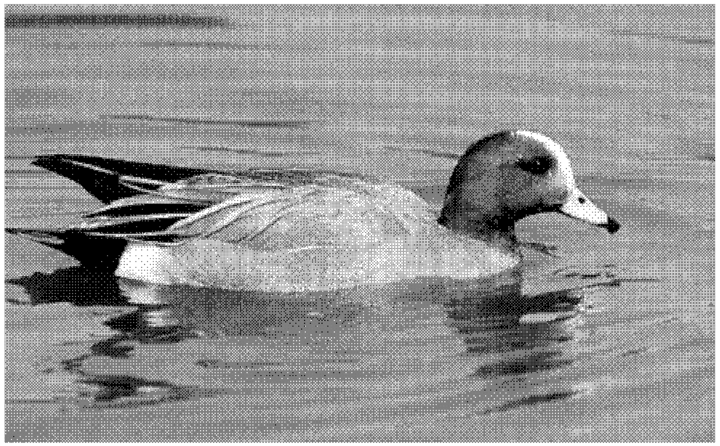
Plate 12.4



Egretta garzetta garzetta بلشون أبيض – أبو بليقة

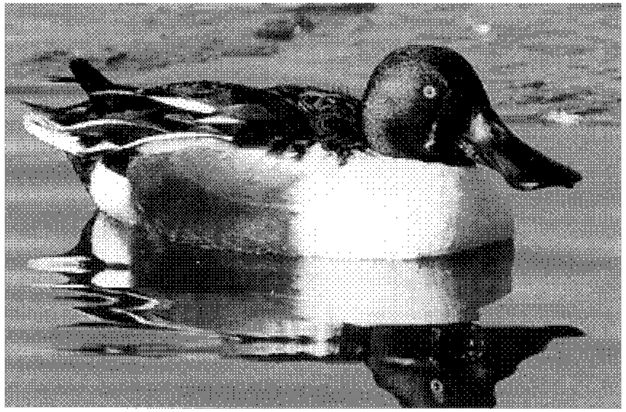


Phoenicopterus ruber roseus بشاروش - نحام

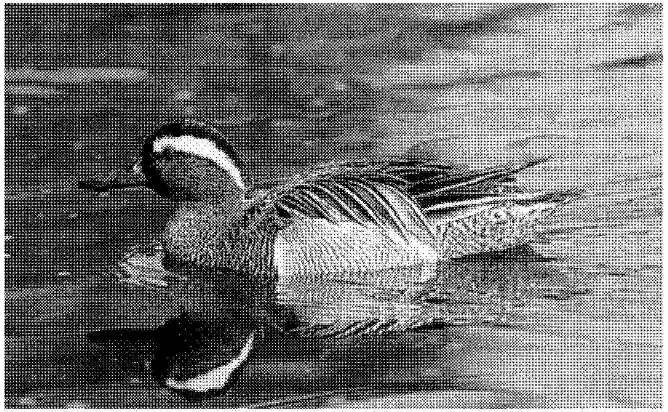


Anas penelope صواى

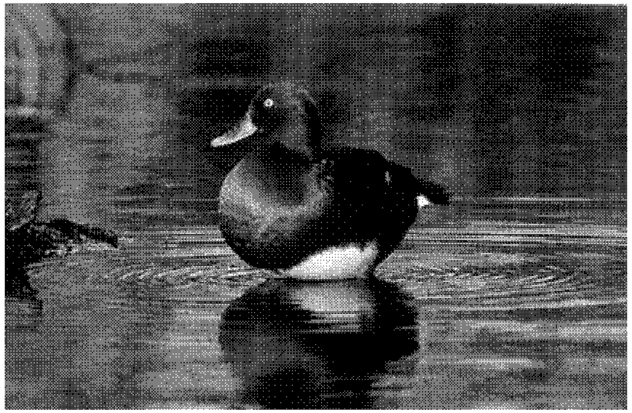
Plate 12.5



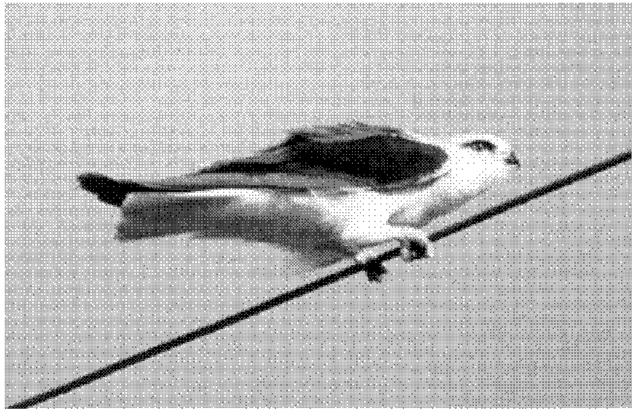
Anas clypeata كبش



Anas querquedula شرشير صيفى

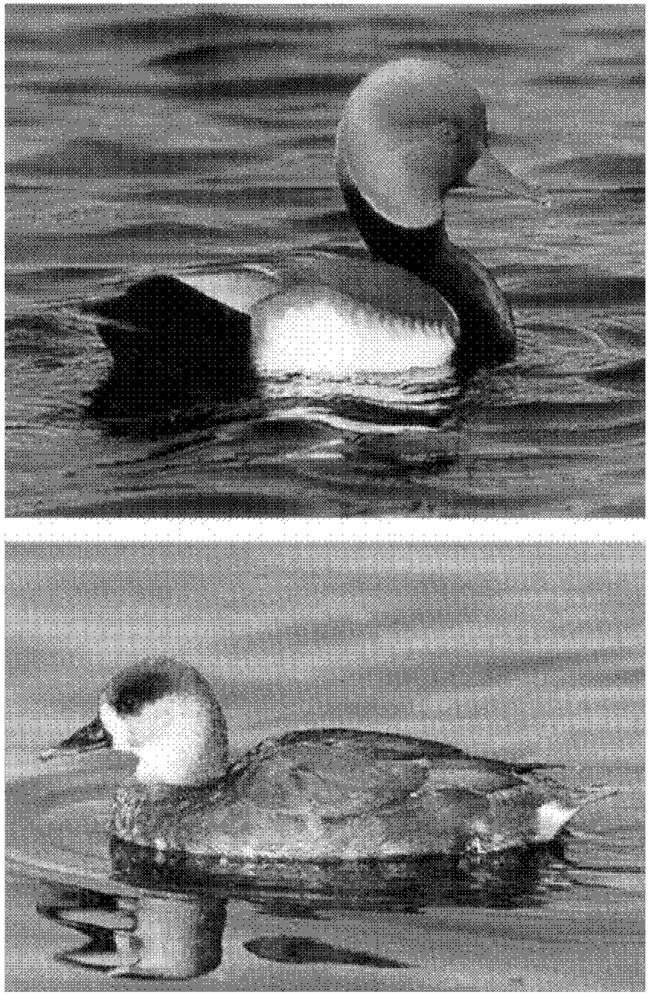


Aytha nyroca زرقاى أخضر



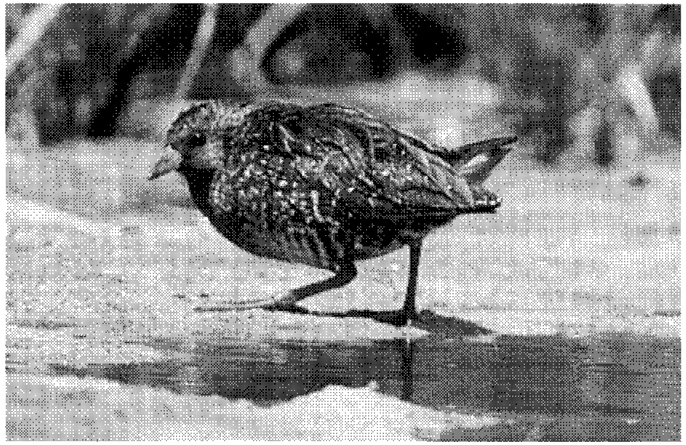
كوهية - حداية*Elanus caeruleus caeruleus*

Plate 12.6



Netta rufina **Top: ♂, Bottom: ♀** ونس

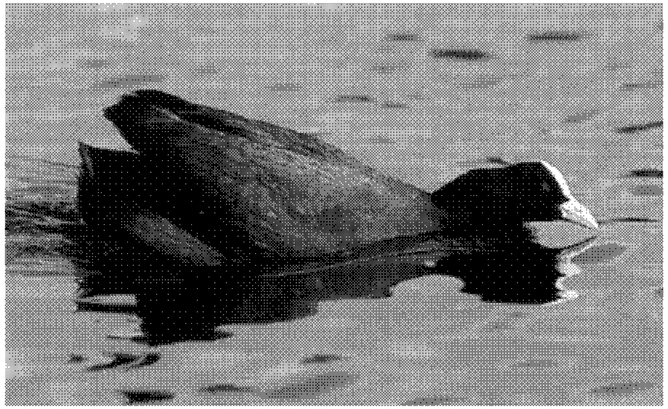
Circus aeruginosus aeruginosus دراع



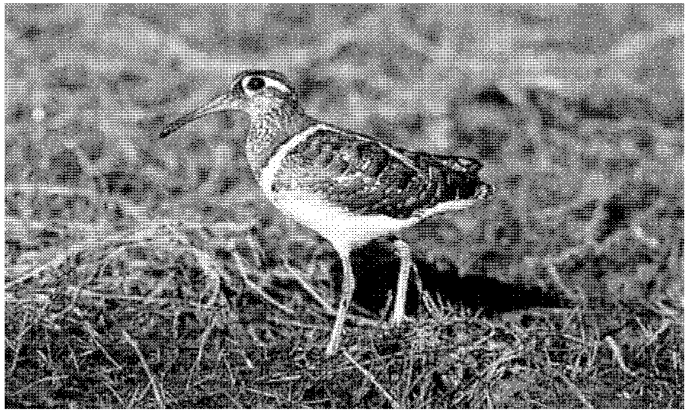
Porzana porzana مرعة منقطة

Plate 12.7

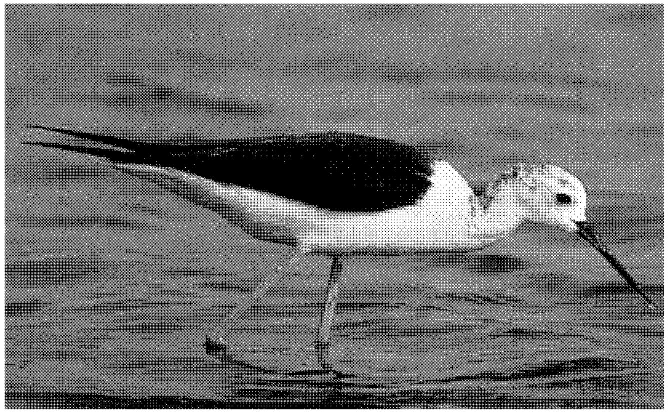
Porphyrio porphyrio madagascariensis دجاجة سلطانية



Fulica atra atra غر

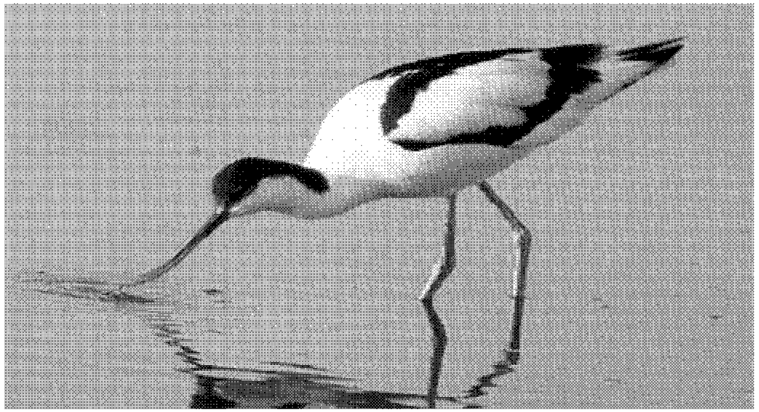


Rostratula benghalensis benghalensis بكاشين مزرق - شنقب

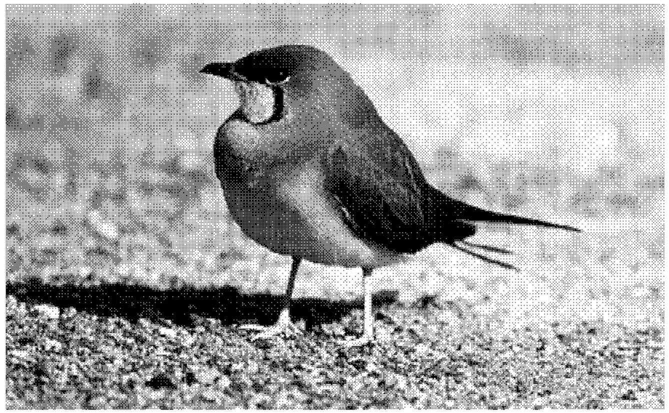


Himantopus himntopus himntopus أبو المغازل – أبو قصبة

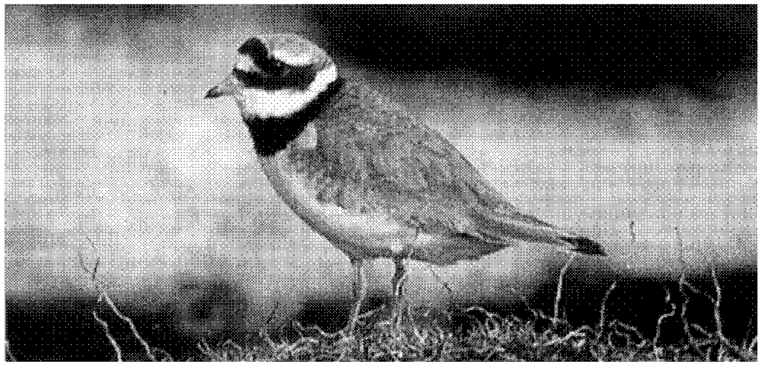
Plate 12.8



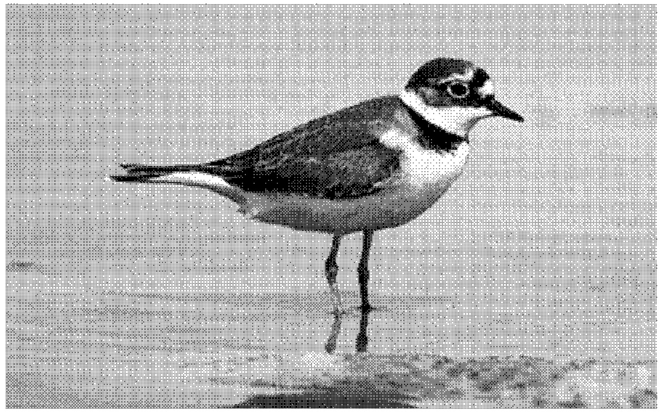
Recurvirostra avosetta حليبى - نكات



Glareola pratincola pratincola أبو اليسر



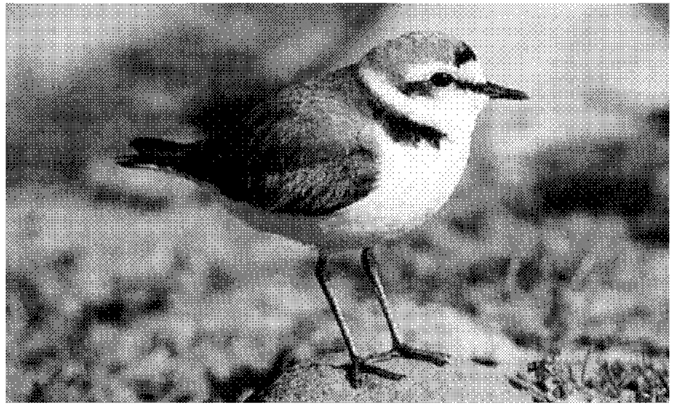
Charadrius hiaticola tundrae زقزاق - قطقاط متوج كبير



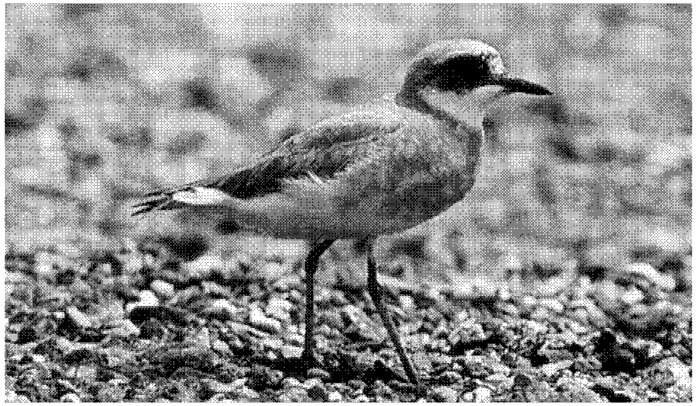
Charadrius dubius curonicus قطقاط متوج صغير

Plate 12.9

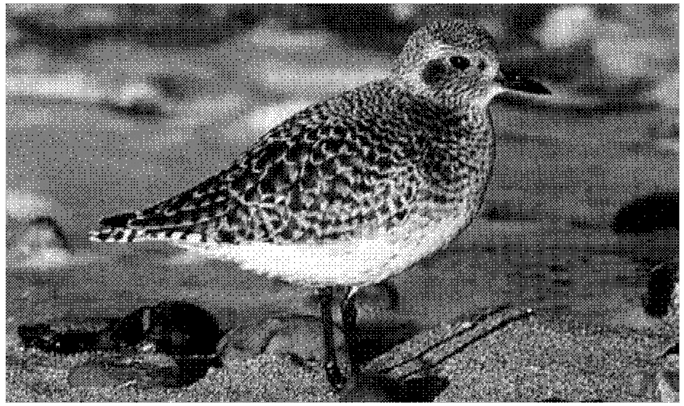
Charadrius pecuarius allenbyi قطقاط بنى



Charadrius alexandrinus alexandrinus قطقاط أبو الرؤوس

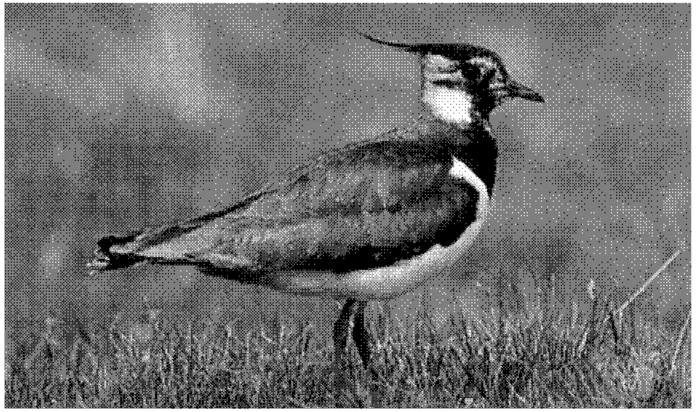


Charadrius leschenaultii قطقاط الرمل الكبير

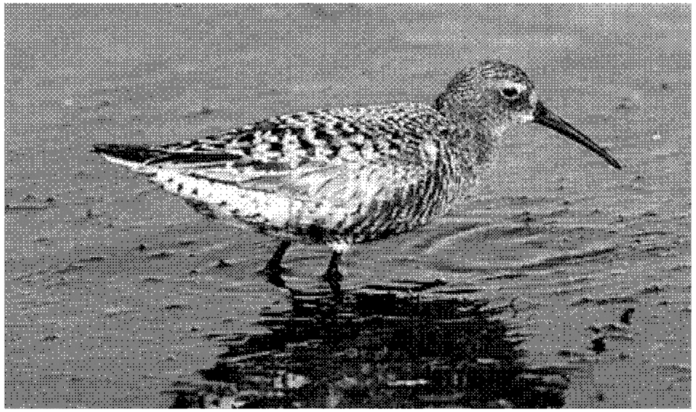


Pluvialis squatarola قطقاط رمادى

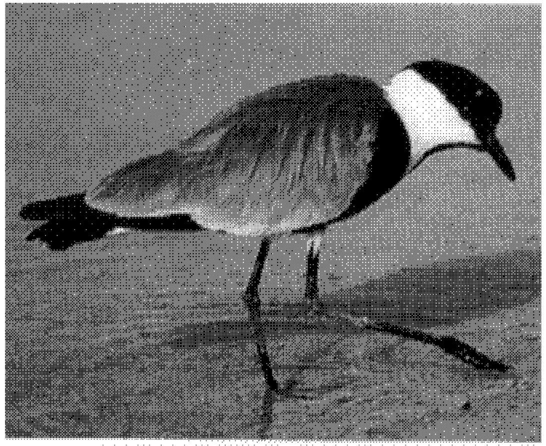
Plate 12.10



Vanellus vanellus زقزاق شامى

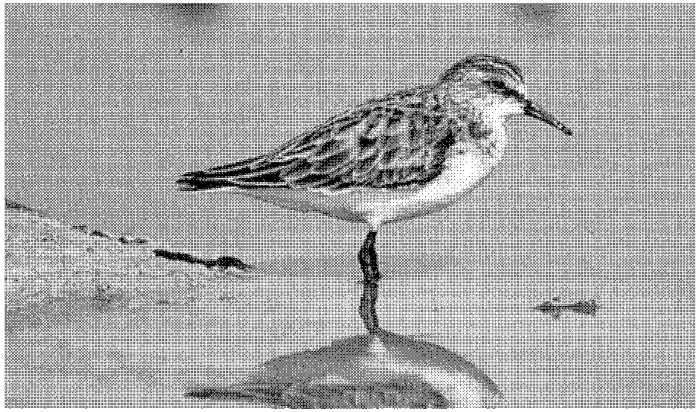


Calidris ferruginea دريجة كرواتية

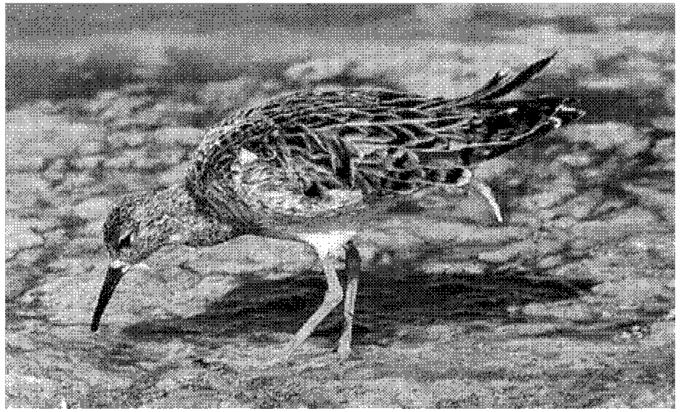


Hoplopterus spinosus زقزاق – أبو زفر

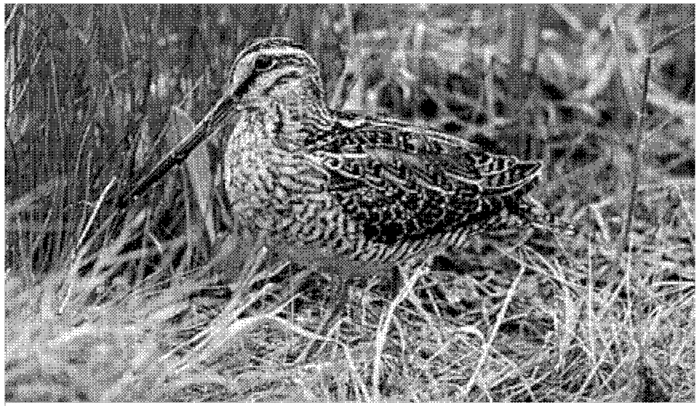
Plate 12.11



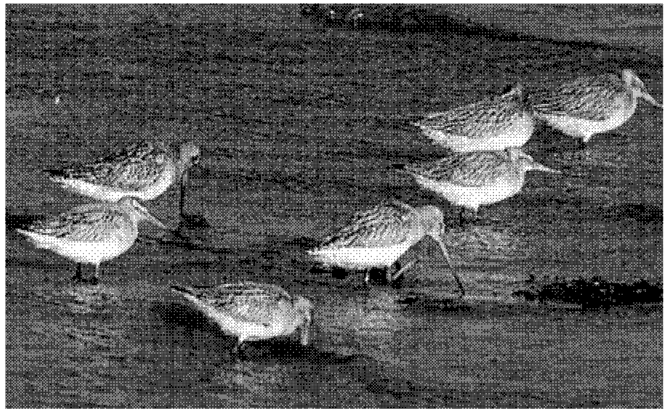
Calidris minuta كروان الماء



Philomachus pugnax بياض - حجوالة

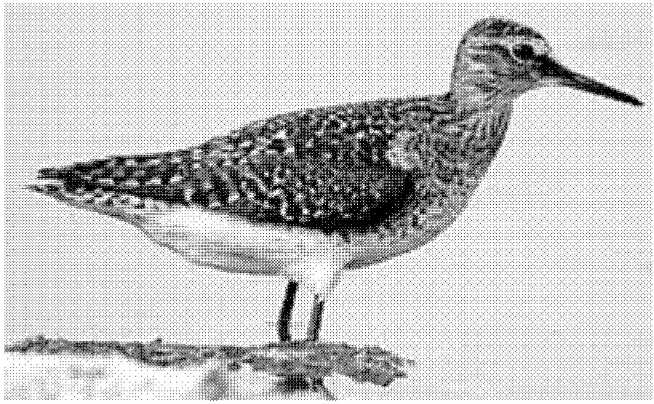


Gallinago galinago galinago بكاشين - شنقب

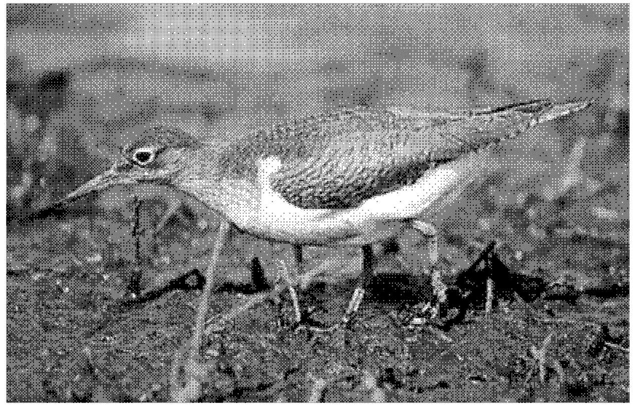


Limosa limosa limosa بقويقة سوداء الذنب

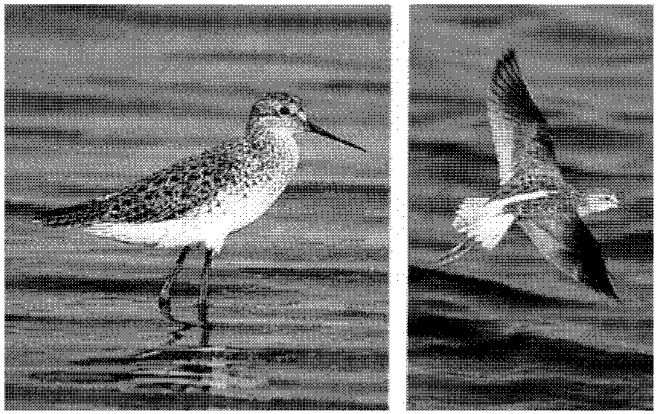
Plate 12.12



Tringa glareola طيطوى الغياض



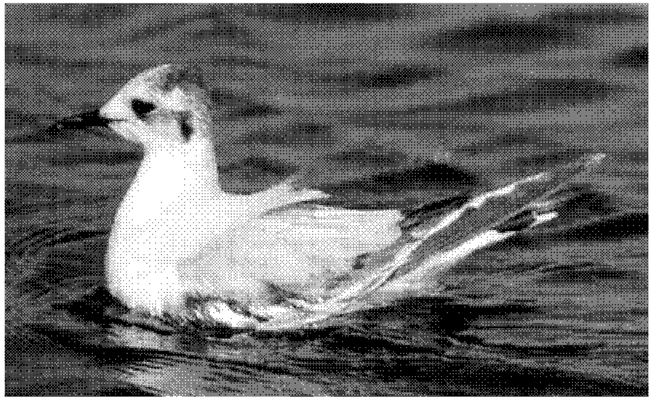
Actitis hypoleucos طيطوى



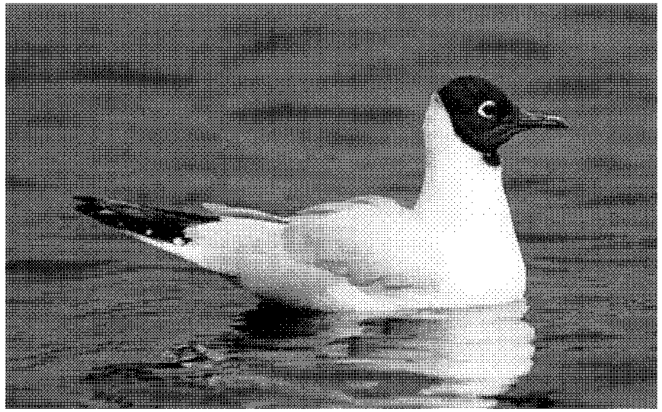
Tringa stagnatillis طيطوى المستنقع

Larus ichthyaetus نورس السمك

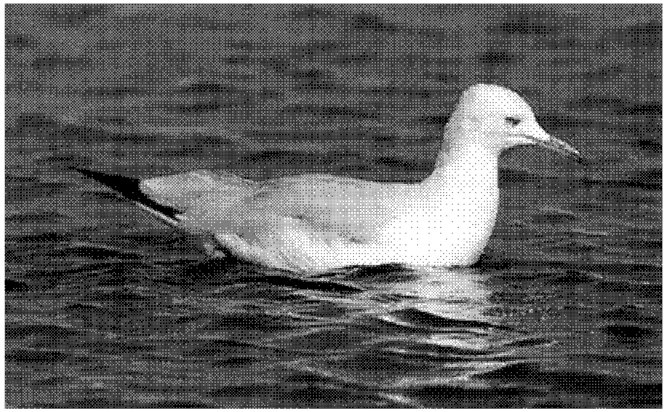
Plate 12.13



Larus minutus نورس صغير



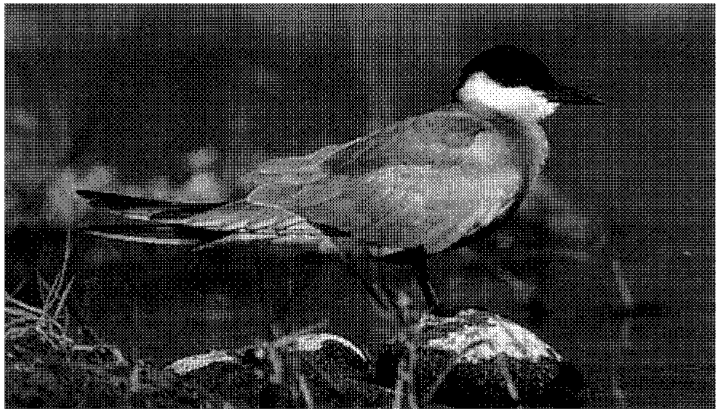
Larus ridibundus نورس اسود الراس



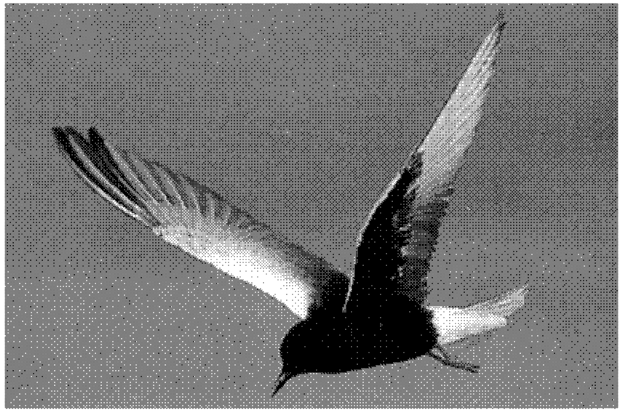
Larus genei نورس قرقطى

Larus fuscus fuscus نورس دغبة - جوكة

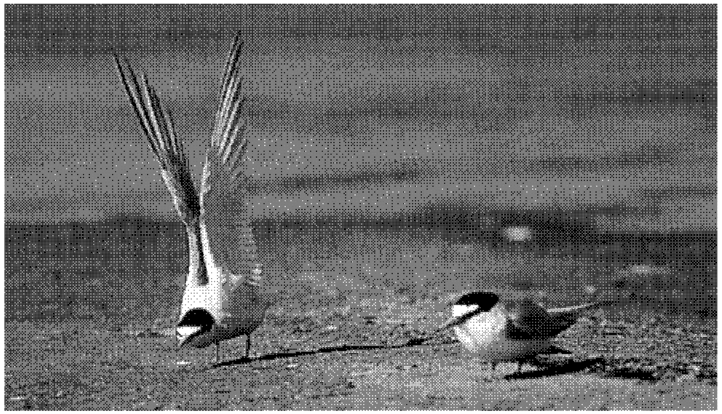
Plate 12.14



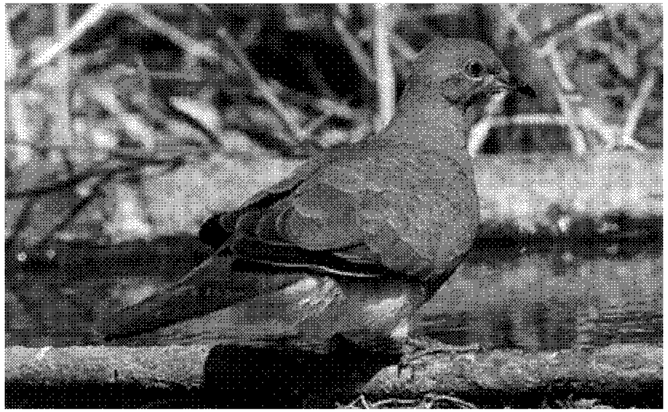
Chlidonias hybrida hybrida خطاف أبيض الخد



Chlidonias leucoptera خطاف أسود الجناح – أبو دفة

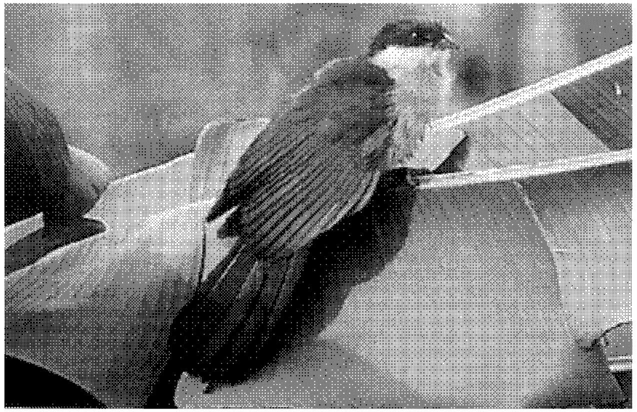


Sterna albifrons albifrons خطاف صغير – دغبز

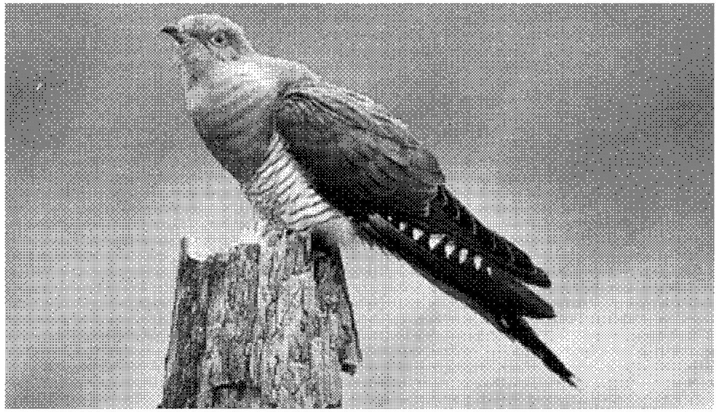


Streptopelia senegalensis aegyptiaca يمام بلدى

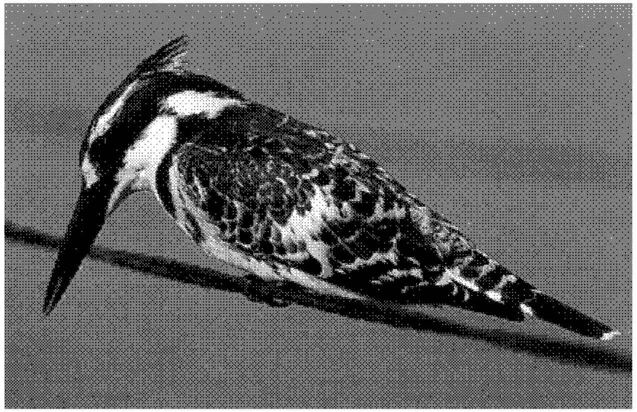
Plate 12.15



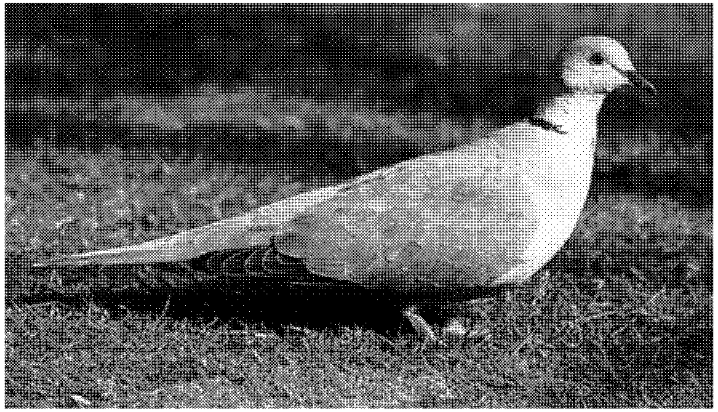
Centropus senegalensis aegyptius مك - كوكو



Cuculus canorus canorus هوهو - وقواق



Ceryle rudis rudis صياد السمك الأبقع - كريللا



Streptopelia decaoclo decaoclo يمام مطوق

Plate 12.16

Tyto alba alba بوم مصاص – أم الصخر

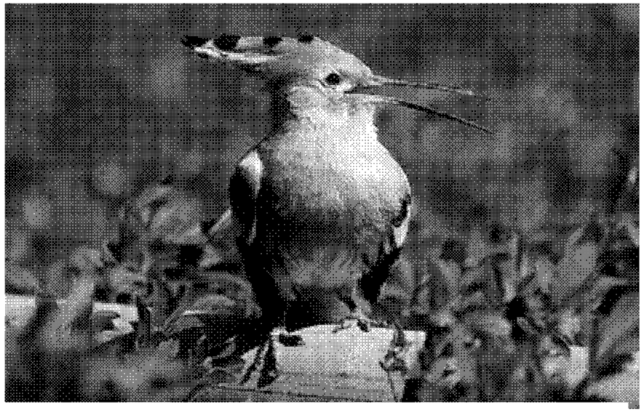
Athene noctua saharae أم الصخر

Plate 12.17

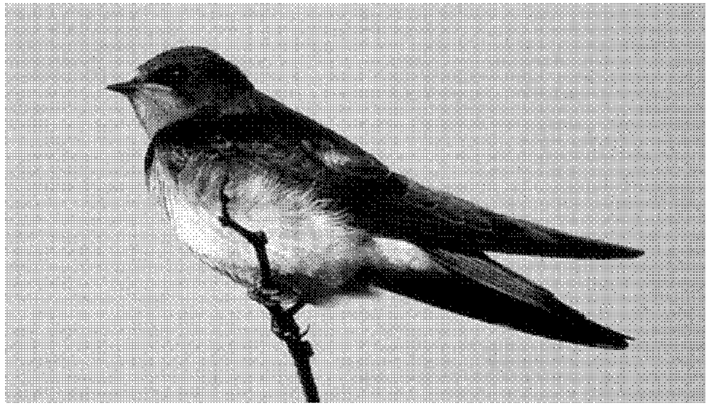
Athene noctua glaux أم قويق

Alcedo atthis atthis صياد السمك - رفراف

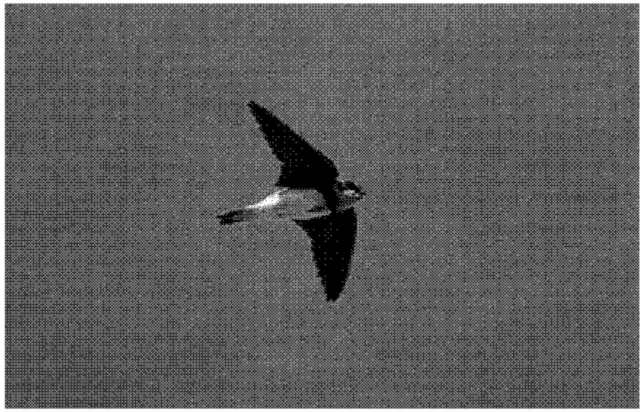
Plate 12.18



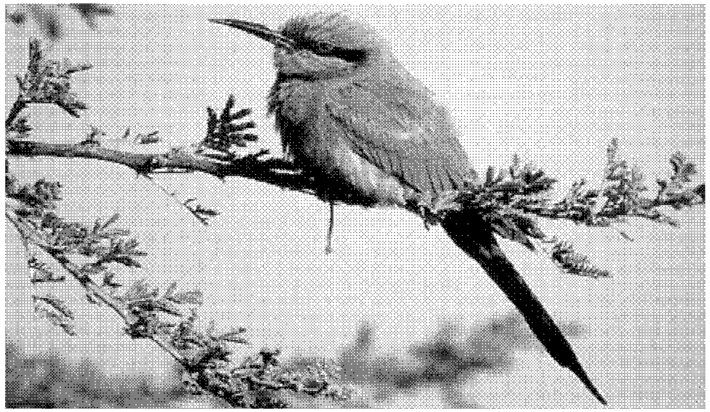
Upupa epops epops هدهد



Hirundo rustica rustica عصفور الجنة

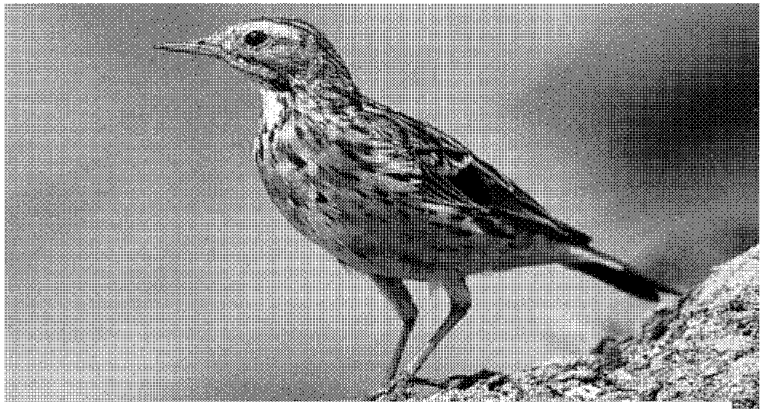


Riparia riparia riparia سنونو

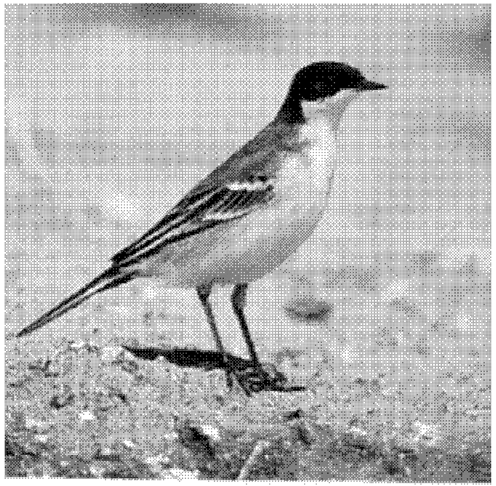


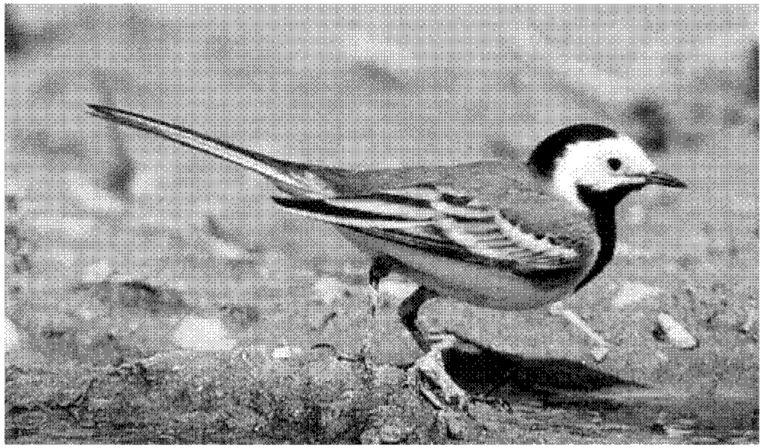
Merops orientalis cleopatra وروار - خضير

Plate 12.19

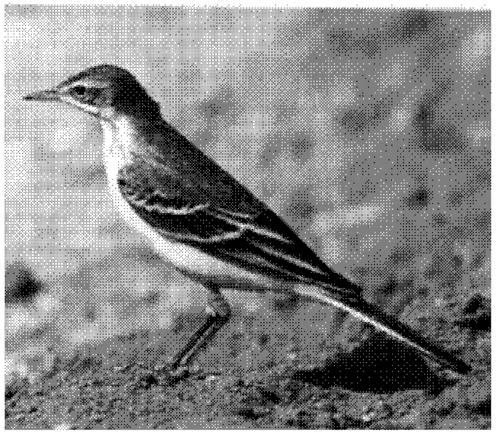


Anthus cervinus بو فصية أحمر الزور



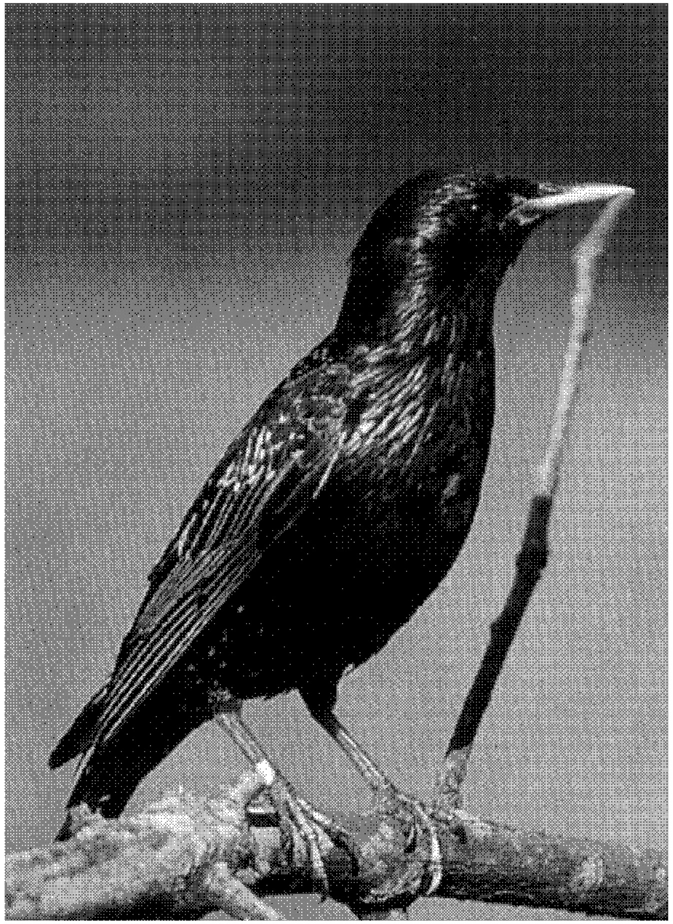


Motacilla alba alba أبو فصادة أبيض

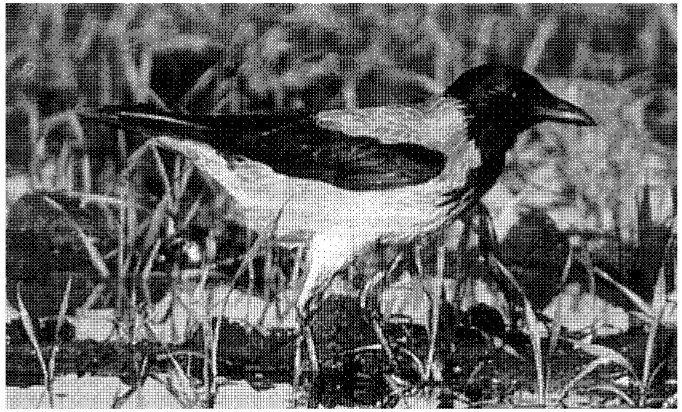


Motacilla flava flavissima أبو فصادة أصفر
Top: ♂, Bottom: ♀

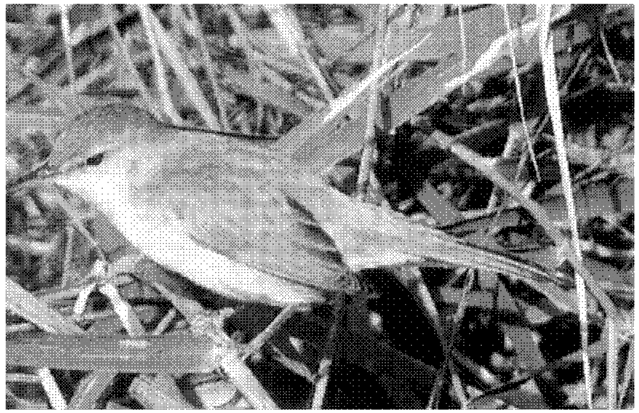
Plate 12.20



Sturnus vulgaris vulgaris زرزور

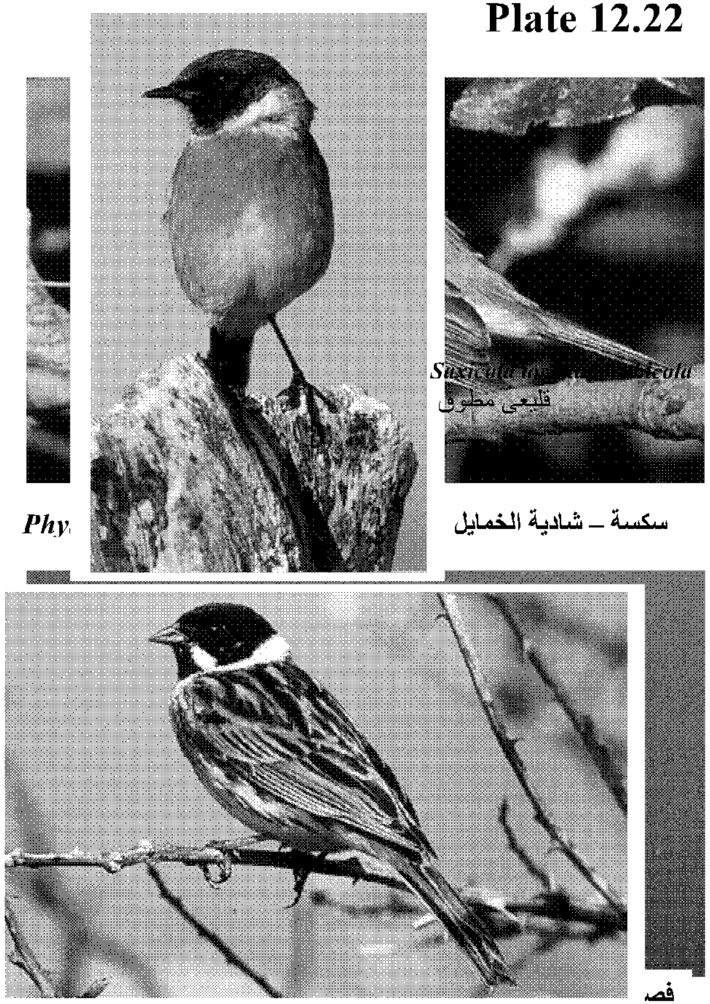


Corvus corone cornix قاق – غراب بلدى



Acrocephalus stentoreus stentoreus هزجة صياحة

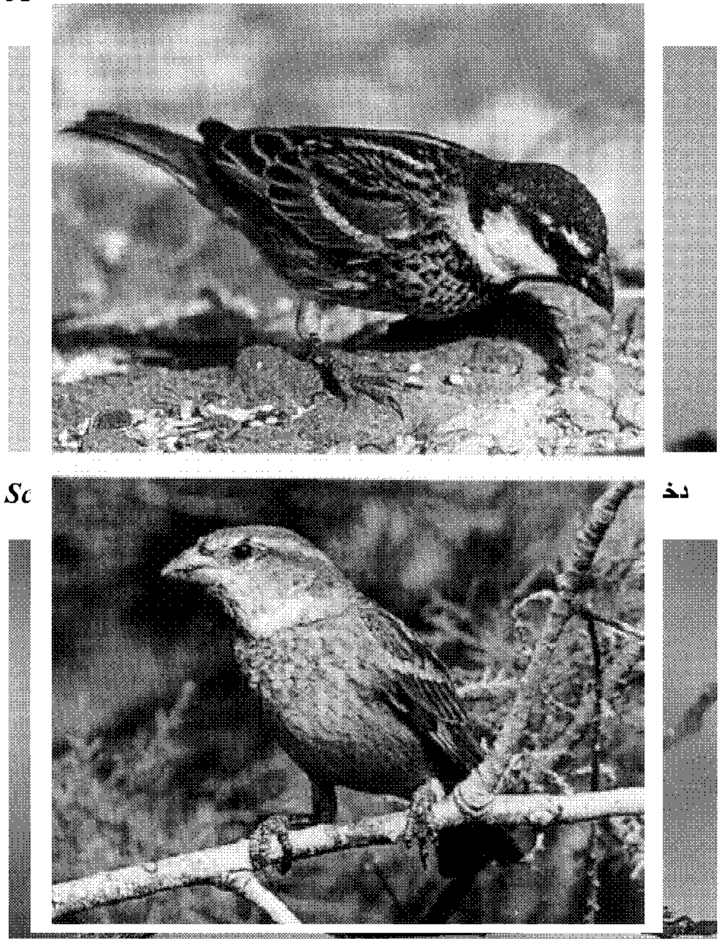
Plate 12.22



Saxicola ... قليعى مطوق

سكسة – شادية الخمايل

Emberiza shoeniclus intermedia درسة الغاب



Passer domesticus niloticus عصفور دورى – عصفور الغيط

Passer hispaniolensis hispaniolensis عصفور أسبانى

Top: ♂, Bottom: ♀

Chapter 13
Mammals

13.1. SPECIES COMPOSITION

Data on the mammals of Egypt in general, and Nile Delta in particular are few and include those of Anderson (1902), Flower (1932), Osborn & Helmy (1980), Wassif (1995) and Hoath (2003). Basuony (2003) dealt with the mammalian fauna in Burullus Protectorate during 2002. A total of 18 species were recorded from the area representing 11 families belonging to four orders (Table 13.1). Other species are expected to be found in the area with further research. Rodents form the largest mammalian group of the area, being represented by seven species (about one-third of the species in the area). Carnivores come next with five species. Each of insectivores and chiropterans were represented by only three species.

The long-eared hedgehog, *Hemiechinus auritus* was collected from Kawm El-Aaqula area, 15 km west of El-Burg. Two specimens were caught alive from their burrow under the vegetation. Flower (1932), Wassif (1953), Setzer (1957) and Osborn & Helmy (1980) collected this hedgehog from Baltim and El-Burg. The subspecific status of this hedgehog is *aegyptius*. By the analysis of stomach contents, insects formed the only food item.

Other insectivorous species were recorded in the area: two shrews *Crocidura flavescens* and *C. floweri* (Basuony 2003). The two species were collected from a site located 7 km west of El-Burg near fishermen's huts. The sandy soil in that area was water-saturated and covered with a dense growth of emergent water plants such as *Phragmites australis* and *Juncus rigidus*. Both species were caught in unbaited pitfall traps. Osborn and Helmy (1980) recorded the Giant Musk Shrew *Crocidura flavescens* from Baltim. Both species are reported to inhabit richly weeded canal margins in Nile Delta and Valley, where they were found in fields and gardens and dry wells in summer (Flower 1932, Hoogstraal 1962). Flower (1932) collected only

one specimen from the stomach of a cattle egret. These species were not recorded from sites west of 31°E longitude in the northern coastal region of Nile Delta.

Table 13.1. **Systematic arrangement of the mammals recorded from Burullus Protectorate (Basuony 2003).**

Order	Family	Species	English name	Arabic name
Insectivora	Erinaceidae	*Hemiechinus auritus*	Long eared hedgehog	قنفذ
	Soricidae	*Crocidura flavescens*	Giant musk shrew	عرسة
		Crocidura floweri	Flower's shrew	زباب الزهور
Chiroptera	Pteropodidae	*Rousettus aegyptiacus*	Egyptian fruit bat	خفاش مصرى
	Rhinopomatidae	*Rhinopoma macrophyllum*	Greater mouse-tailed bat	خفاش ابو ديل صغير
	Vespertilionidae	*Pipistrellus kuhlii*	Kuhl's Pipistrelle	خفاش كولى
Rodentia	Cricetidae	*Gerbillus andersoni*	Anderson's Gerbil	بيوضى
		Psammomys obesus	Fat sand rat	جرذ
	Muridae	*Arvicanthis niloticus*	Nile or field rat	فأر الغيط
		Rattus rattus	Black rat	جرذ اسود
		Rattus norvegicus	Brown rat	جرذ المجارى
		Mus musculus	House mouse	سيسى – فأر
		Acomys cahirinus	Cairo spiny mouse	عرسة
Carnivora	Canidae	*Canis aureus*	Jackal	ابن آوى
		Vulpes vulpes	Red fox	ثعلب
	Mustelidae	*Mustela nivalis*	Weasel	ابن عرس
	Viverridae	*Herpestes ichneumon*	Egyptian mongoose	نمس
	Felidae	*Felis chaus*	Jungle cat	قط برى
4	**11**	**18**		

Records of bats from the study area are available in the literature and are herein sited. Bat species were recorded from Baltim (Anderson 1902; Madkour 1977; Qumsiyeh 1985). Many individuals of the large fruit bat *Rousettus aegyptiacus* were seen flying at the coastal area of Kawm Al-Aaqula (Basuony 2003). *Rhinopoma microphyllum* and *Pipistrellus kuhlii,* which were reported from the area (Qumsiyeh 1985) might have been among the many microchiropteran bats observed in the gardens around Baltim. Verification of the identification of these species requires the collection of different specimens.

The rodents of the area belong to two families. Cricetidae includes two species recorded for the first time in this area, namely *Gerbillus andersoni* and *Psammomys obesus*. The subspecific status of *Gerbillus andersoni* based on cranial characters was *andersoni*. It is a nocturnal species that inhabits sandy areas. The fat sand rat, *Psammomys obesus,* is recorded in the northern Sinai and the northern part of the Eastern Desert. This species has not been recorded from Nile Delta except for one specimen collected from Quweisna and recorded as subspecies *obesus*. In Basuony's

study (2003), materials were collected from the sandy islets of the lake; Mastroh and Al-Kawm Al-Akhdar. In this area it inhabits saline soils and salt marshes with stands of succulent halophytic plants such as *Anabasis articulata.* The fat sand rat is a colonial desert rodent and is strictly diurnal; however, Atallah (1967) reported its nocturnal activity in Jordan.

Muridae is the second largest rodent family in the study area and is represented by five common species. *Arvicanthis niloticus, Rattus rattus, R. norvegicus, Mus musculus* and *Acomys cahirinus* are diurnal, nocturnal and feed on vegetables and seeds. Burrows are shallow and usually under shrubs. The colour *of Mus musculus* specimens captured during this survey is darker when compared with the specimens from other Egyptian localities. Four individuals were captured from one burrow in Deshimi islet that contained insect remains.

Carnivores of Burullus area include only five species belonging to three families. Canidae is represented by two species *Canis aureus* and *Vulpes vulpes*. Basuony (2003) collected *Canis aureus* from the lower part of the drainage canal feeding the lake. The canal in that area is chocked with dense marsh vegetation. Howling of this jackal was frequently heared throughout the study area. This species has not been previously recorded from the northern Nile Delta. Recent studies suggest that this form is in fact a wolf (Ferguson 1981).

The Red Fox *Vulpes vulpes* is very numerous in areas around the lake shores. Individuals and their tracks were seen throughout the area, where it seems to inhabit date and fruit groves, cultivated areas and suburban gardens, commonly seen during daylight hours. It feeds on birds, rodents and insects (Basuony 1998). This fox belongs to subspecies *aegyptiaca* which is widespread in Nile Delta and Valley.

The weasel *Mustela nivalis* was recorded for the first time in Kafr El-Sheikh and the rest of Nile Delta (Basuony 2003). The collected specimen was from El-Hanafy village, 15 km west of El-Burg. This species has also been collected at the fringes of Nile Delta (Osborn and Helmy 1980).

The Egyptian Mongoose, *Herpestes ichneumon,* inhabits the cultivated areas of Nile Valley and Delta, near water. Basuony (2003) recorded only one specimen, jumping from the islet to the adjacent reedbed across a water canal. It is a terrestrial species, but readily enters water and swims well. It feeds on rodents, birds, poultry, reptiles, frogs and various aquatic and terrestrial invertebrates (Harrison and Bates 1991).

The jungle cat *Felis chaus* was observed in the *Phragmites australis* reed swamps in Al-Kawm Al-Akhdar islet (Basuony 2003). The previous record of this cat from Nile Delta comes from its southern and northwestern corners (Osborn & Helmy 1980). Basuony (2003) record adds the northern Delta to the national geographical range of this species.

13.2. ZOOGEOGRAPHICAL AFFINITY

Of the eighteen species recorded from Burullus and adjacent areas, seven are widely distributed in the world *(Pipistrillus kuhlii, Rattus rattus, Rattus norvegicus, Mus musculus, Canis aureus, Vulpes vulpes* and *Mustela nivalis)*. Afrotropical species with wide distribution in Africa south of the Sahara include *Crocidura flavescens, Rousettus aegyptiacus, Arvicanthis niloticus, Acomys cahirinus* and *Herpestes ichneumon*(Table 13.2). The latter species occurs to the north through the eastern Mediterranean to Turkey. The same can be said for *Rousettus aegyptiacus;* the distribution of which reaches Cyprus and Iran.

Table 13.2. **Mammals recorded from Burullus Wetland and their major zoogeographical subdivisions (Qumsiyeh 1985). AF=Afrotropical, SS= Saharo-Sindian, PL= Pluriregional, WD= Widespread and EN= Endemic species.**

Species	Zoogeographical subdivision				
	AF	SS	PL	WD	EN
Acomys cahirinus	+				
Arvicanthis niloticus	+				
Canis aureus				+	
Crocidura flavascens	+				
Crocidura floweri					+
Felis chaus			+		
Gerbillus andersoni		+			
Hemiechinus auritus		+			
Herpestes ichneumon	+				
Mus musculus				+	
Mustela nivalis				+	
Pipistrellus kuhlii				+	
Psammomys obesus		+			
Rattus norvegicus				+	
Rattus rattus				+	
Rhinopoma microphyllum		+			
Rousettus aegyptiacus	+				
Vulpes vulpes				+	
18	**5**	**4**	**1**	**7**	**1**

Four species occurring in Burullus area are distributed in the intermediate zone between the Palearctic and the Ethiopian regions (i.e. North Africa, Africa and southwest Asia), with some reaching the Oriental region. These are: *Rhinopoma microphyllum, Hemiechinus auritus, Gerbillus andersoni* and *Psammomys obesus.* These species are adapted to semidesert habitats especially oases and wadi beds and may be termed Saharo-Sindian (Atallah 1977) or Saharo-Arabian (Zohary 1973). The jungle cat *Felis chaus* represents the pluriregional species that are common to

the Mediterranean and Saharo-Sindian regions. On the other hand, *Crocidura floweri* is the only endemic species of this collection that is restricted to Egyptian Nile Valley.

By virtue of the location of Egypt, it is surprising that the Mediterranean element is not pronounced even if one includes such species as *Pipistrellus kuhlii* and other species of possible Mediterranean origin. *Pipistrellus kuhlii* could not be clearly assigned to a given zoogeographic region because of their widespread distribution; however this species was considered by Gaisler *et al.* (1972) to be Mediterranean, while Qumsiyeh (1985) classified it as a widespread species.

Five mammalian species recorded from Lake Burullus are found also in Nile Delta and they seem to have never crossed into the Eastern Desert and/or Sinai Peninsula (*Crocidura flavescens, Crocidura floweri, Rhinopoma microphyllum, Herpestes ichneumon* and *Arvicanthis niloticus*).

13.3. MAMMALIAN HABITATS

Coastal sand dunes, sand and mud flats, salt marshes, islets, swamps, agricultural land and artificial landscapes represent the basic recognizable habitat types in Burullus area (Basuony 2003). Sand and mud flats, salt marshes, coastal sand dunes and islets include psammophytic and halophytic communities. Swamps include reeds and large plant communities along the margins of the lake. Agricultural land and artificial landscapes include cropland, towns, villages canals and industrial sites. The habitat of the coastal halophytic communities is inhabited by the largest number of the mammalian species (17 species representing 94% of the mammalian species collected). Agricultural land and artificial landscapes come next and are inhabited by thirteen species (72%), whereas only four species (22% of mammalian species) were recorded from bogs and salt marshes (Table 13.3).

Five species belonging to the genera *Rousettus, Rhinopoma, Pipistrillus, Gerbillus* and *Mustela* are restricted to only one habitat type. Ten species *Hemiechinus auritus, Crocidura flavescens, Crocidura floweri, Psammomys obesus, Arvicanthis niloticus, Rattus rattus, Rattus norvegicus, Mus musculus, Acomys cahirinus* and *Vulpes vulpes* were recorded in two habitat types. Only three species were found in three habitat types (*Canis aureus, Herpestes ichneumon* and *Fells chews*).

Table 13.3. **Mammals recorded from Burullus Wetland and adjacent area. SF=mud and sand flats; SM= salt marshes; CS= coastal sand dunes; IS= islets, reefs and banks; CP= crop land; TV= towns, villages and industrial sites.**

Species	Coastal habitats				Bogs and marshes	Agricultural and artificial lands		Total	
	SF	SM	CS	IS		CP	TV	No.	%
Hemiechinus auritus	+					+		**2**	**28.6**
Crocidura flavescens	+	+	+	+			+	**5**	**71.4**
Crocidura floweri		+	+			+		**3**	**42.9**
Rousettus aegyptiacus				+				**1**	**14.3**
Rhinopoma microphyllum			+					**1**	**14.3**
Pipistrellus kuhlii			+					**1**	**14.3**
Gerbillus andersoni	+		+	+				**3**	**42.9**
Psammomys obesus		+		+	+			**3**	**42.9**
Arvicanthis niloticus				+		+		**2**	**28.6**
Rattus rattus			+			+	+	**3**	**42.9**
Rattus norvegicus	+		+			+	+	**4**	**57.1**
Mus musculus			+	+		+	+	**4**	**57.1**
Acomys cahirinus				+			+	**2**	**28.6**
Canis aureus		+			+	+		**3**	**42.9**
Vulpes vulpes		+		+			+	**3**	**42.9**
Mustela nivalis							+	**1**	**14.3**
Herpestes ichneumon		+		+	+	+		**4**	**57.1**
Felis chaus	+	+	+	+	+	+	+	**7**	**100**
18	**5**	**7**	**9**	**10**	**4**	**9**	**8**	**7**	

A statistical comparison of the mammalian faunal assemblages of the habitat types of Burullus area was carried out using Morton and Davidson's similarity index (Basuony 2003). The similarity index between the mammalian faunal assemblages was relatively low. The highest value of similarity index (0.73) was recorded between the coastal habitats and agricultural and artificial lands. On the other hand, the lowest similarity index (0.35) was found between the mammalian assemblages of bogs and marshes on one hand, and agricultural and artificial lands on the other hand. A similarity index of 0.38 was calculated for the mammalian fauna of coastal habitats and bogs – marshes habitats.

13.4. SPECIES ACCOUNT

Order Insectivora

Family Erinaceidae

1- Hemiechinus auritus **(Gmelin, 1770)**

Common names: Long Eared Hedgehog; قنفذ

World distribution: Coast of Libya and Egypt to Asia Minor, northern Arabia, southern USSR, Iran, Pakistan, Chinese Turkistan and Mongolia.

National distrbution: Mediterranean coast, Nile Delta, Nile Valley south to Samalut and El-Faiyum.

Burullus observation sites: Kawm El-Aaqula and Abu Slyman.

Description: A small hedgehog with long ears. Face is pale brown to buffy white; belly is white and base brownish. A foot is whitish to pale brown. Tips of dorsal spines white. Gap in spines of forehead lacking. Adult head and body length averages 181 mm, tail 24 mm, foot 35 mm, ear 41 mm and condyloincisive length 44.7 mm.

Comparison: *Hemiechinus auritus* is distinguishable from other Egyptian hedgehogs by smaller dimensions, paler colour and lack of gap in forehead spines.

Habitats and ecology: It inhabits gardens, olive gardens, cultivated areas and more densely vegetated areas of the coastal desert. Nocturnal species and feeds on insects (Osborn & Helmy 1980) as well as lizards (Saleh and Basuony 1998).

Status: Lower Risk (least concern).

Remarks: This hedgehog has been collected only from Baltim and El-Burg by Flower (1932), Wassif (1953), Setzer (1957) and Osborn & Helmy (1980). This study adds another locality of this species in the area. The subspecies occurring in Nile Delta is *aegyptius* (Osborn & Helmy 1980)

Family Soricidae

2- Crocidura flavescens deltae **Heim de Balsac and Barloy, 1966**

Common names: Giant Musk Shrew; عرسة

World distribution: Egypt, Sudan, Ethiopia and the rest of Africa south into South Africa; West Africa north to Sierra Leone.

National distrbution: Nile Delta and Valley, as far south as Dahshour and El-Faiyum.

Burullus observation sites: West of El-Burg.

Description: Large white toothed shrews. Head and body length 70 mm or more. Fur short and dense. Ear scarcely protruding beyond fur. Tail with conspicuous and scattered bristle hairs on proximal two-thirds. Venter dark gray and hind foot length 18 mm or more. Condyloincisive length is 15 mm or more.

Comparison: *Crocidura flavescens* is distinguishable from other species of Egyptian shrews by its larger size.

Habitats and ecology: This species inhabited richly weeded canal margins in Nile Delta and Valley (Hoogstraal 1962) and dry wells in summer. It is nocturnal species. Nests are balls of grass and always moist and feeds on insects as well as snail shells (Hoogstraal 1962).

Status: Lower Risk (least concern).

Remarks: Osborn & Helmy (1980) recorded this species from Baltim only.

***3- Crocidura floweri* Dollman, 1915**

Common name: Flower's shrew; زباب الزهور

World distribution: Endemic in Egypt.

National distrbution: Nile Delta and Valley, Wadi El-Natroun and El-Faiyum.

Burullus observation sites: El-Hanafy.

Description: Small white toothed shrews. Head and body length 72 mm or less. Fur short and dense. Ear scarcely protruding beyond fur. Tail with inconspicuous and limited bristle hairs on proximal one-half. Dorsum brownish; cranium convex and hind foot length 12 mm or more. Condyloincisive length 20 mm or less.

Comparison: This species can be distinguished from any other Egyptian shrews by relatively small size but larger than *C. nana.*

Habitats and ecology: This shrew inhabits fields and gardens.

Status: Lower Risk (least concern).

Remarks: Flower (1932) collected only one specimen from the stomach of cattle egret.

Order Chiroptera

Family Pteropodidae

***4- Rousettus aegyptiacus* (Geoffroy, 1810)**

Common names: Egyptian Fruit Bat; خفاش مصرى

World distribution: Baluchistan, south-east Iran, Kishim Island in the Persian Gulf through to Arabia, Turkey, Cyprus and Africa, from Egypt and Eritrea west to Ghana and south to Angola and the Cape.

National distribution: Most cultivated areas of Nile Valley and Delta.

Habitats: It roosts in large colonies in wells, old ruins, tombs and deserted houses.

Ecology: Nocturnal and become active shortly after dusk and have another peak of activity in the early morning hours. It feeds on sycamore, mulberries, dates and figs (Anderson 1902; Madkour 1977).

Status: Lower Risk (least concern).

Remarks: Anderson (1902) recorded this species from Baltim.

Family Rhinopomatidae

***5- Rhinopoma microphyllum* (Brunnich, 1782).**

Common name: Greater Mouse- tailed Bat; خفاش ابو ديل صغير

World distribution: Morocco, Senegal and Nigeria to East Africa, Arabia, Iran, Afghanistan, Pakistan, India, Thailand and Sumatra.

National distribution: Nile Valley, particularly around Cairo, and Delta region.

Habitats: Dry caverns, ruins ancient temples and old buildings.
Ecology: Nocturnal. Pellets of the owl, *Tyto alba,* is containing three skulls of this bat (Dor 1947).
Status: Lower Risk (least concern).
Remarks: Anderson (1902) recorded this species from Baltim.

Family Vespertilionidae

***6- Pipistrellus kuhlii* (Kuhl 1819)**

Common name: Kuhl's Pipistrelle; **خفاش كولى**
World distribution: From southern Europe to Pakistan and most of Africa; from Morocco to Egypt and south to South Africa.
National distribution: Around human populated areas in northern Egypt.
Habitats: Crevices in the walls and roofs of buildings as well as underground tunnels.
Ecology: Colonial species.
Status: Widespread but not common.
Remarks: Anderson (1902) recorded this species from Baltim.

Order Rodentia

Family Cricetidae

***7- Gerbillus andersoni andersoni* De Winton, 1902**

Common names: Anderson's Gerbil, **بيوضى**
World distribution: Jordan, Egypt, Libya and Tunisia.
National distrbution: Northeastern Sinai.
Burullus observation sites: Kom El-Aakolla.
Description: Desert gerbil with brownish orange dorsal sides. Side is clear orange and its colour extends onto upper foreleg and heel. A whitish postorbital and postauricular area is small and inconspicuous. Ear and sole is pigmented.
Comparison: *Gerbillus andersoni* can be distinguished from other Egyptian *Gerbillus* by generally darker colour.
Habitats and ecology: Nocturnal species that inhabited sandy areas. However, it does not inhabit more rigorous desert areas (Hoogstraal 1963).
Status: Lower Risk (least concern).
Remarks: This subspecies is darker than subspecies *bonhote.*

***8- Psammomys obesus* Crezschmar, 1828**

Common names: Fat Sand Rat, **جرد**
World distribution: North Africa, Sudan, Arabia and Palestine.
National distrbution: Northern part of Sinai and eastern desert
Burullus observation sites: Mastrouh and Al-Kawm Al-Akhdar.
Description: Stocky rodents. Dorsal surface is blackish to reddish orange while side and venter is yellowish. Short, rounded and densely haired ears.

Tail is thick and shorter than head and body (less than 85%) with black prominent tip. The skull is angular and strongly ridged.

Habitats and ecology: Habitats of *Psammomys obesus* are saline soils and salt marshes with stands of succulent halophytic such as *Anabasis articulata* of the study area. This is a colonial desert rodent. Sand rats are strictly diurnal, but Atallah (1967) testified to its nocturnal activity in Jordan. Tunnels of a burrow system are seldom deeper than 0.5 m., but may be several meters in length. The number of openings is 6-21 with an average of 11 (Osborn and Helmy 1980).

Comparison: The only Egyptian rodent with which *Psammomys obesus* might be confused is *Meriones crassus*, however, slightly longer tail and ears, bicoloured tail tip, which belly in *Meriones* distinguish that species from *Psammomys obesus.*

Status: Lower Risk (least concern).

Remarks: This species has not been recorded from Delta region except one specimen collected from Quweisna and recorded as subspecies *obesus* (Osborn and Helmy 1980)

Family Muridae

***9- Arvicanthis niloticus* (Desmarest, 1822)**

Common names: Nile or Field Rat; **فار الغيط**

World distribution: Northeastern Africa from Egypt and Sudan south to Kenya and Tanzania west to Uganda, Nigeria and Sengal. Also southwestern Arabia.

National distrbution: Nile Delta andValley as far south as Aswan. Also Kharga and Dakhla, Wadi Natrun and Fayoum.

Description: Large big-headed, rather slim rat. Upper parts rather grizzled-black and yellow. Flanks paler and coat coarse. Dark stripe down center of back may be distinct running from top of the head to the base of the tail. Underside whitish to greyish. Hairs on rump longer and more or less tinged yellow to orange. Feet buffish orange to blackish above. Head large, rather pointed.Whiskers sparse and short. Ears small and rounded, tinged orange. The tail is about 80% of the body length, slender, blackish above, pale below. Fur dense, concealing tail rings. No terminal tuft.

Habitats and ecology: Agricultural areas and margins, canal and railway embankments with good cover, olive groves and gardens. It is recorded around, but apparently never in, human settlements. Active by day and night.

Status: Lower Risk (least concern).

***10- Rattus rattus* (Linnaeus, 1758)**

Common names: House or Black Rat; **جرذ اسود**

World distribution: Cosmopolitan species.
National distrbution: Nile Valley and Delta, coastal towns and certain oases in western desert.
Burullus observation sites: El-Hanafy.
Description: Large murids with relatively harsh pelage that brownish dorsally. Tail is slender and bicoloured and length is more than 100% of head and body. Ear length is more than one-half hind foot length. Skull massive and strongly ridged.
Comparison: *Rattus rattus* differs externally from *R. norvegicus* in having head and body length averaging shorter, tail longer rather shorter than head and body length, and ear more than one-half hind foot length.
Habitats and ecology: It is commensal with man. Diurnal and nocturnal, and feeds on vegetables and seeds.
Status: Lower Risk (least concern).
Remarks: The specimens of the study of Basuony (2003) seem to be darker than that of Sinai.

***11- Rattus norvegicus* (Berkenhout, 1769)**
Common names: Norway or Brown or Sewer Rat; جرذ المجارى
World distribution: Nearly cosmopolitan species due to accidental transportation by man.
National distrbution: Coastal towns, Nile Delta and Valley.
Burullus observation sites: Baltim and El-Hanafy in addition to one specimen accidented by a car in El-Banayen village.
Description: Large murids (as twice as *Rattus rattus*) with relatively harsh pelage that brownish dorsally. Tail is thick and bicoloured and length is less than 100% of head and body. Ear length is less than one-half hind foot length. Skull massive and strongly ridged.
Habitats and ecology: Commensal with man. Mainly nocturnal species. Diet of *R. norvegicus* to be omnivorous.
Status: Lower Risk (least concern).
Remarks: Although this animal is widespread, Osborn and Helmy (1980) collected only one specimen from Baltim and another one from Al-Hamoul.

***12- Mus musculus praetextus* (Brants, 1827)**
Common names: House Mouse; فأر - سيسى
World distribution: Cosmopolitan species.
National distrbution: Mediterranean coastal areas, Nile Valley and Delta and oases of western desert.
Burullus observation sites: Al-Kawm Al-Akhdar and Deshimi islets.
Description: Small murids with soft pelage that grayish to brownish in dorsal surface. Tail is usually slightly longer than head and body length.

Their annulations almost concealed by hairs. The skull is fragile and rounded.

Comparison: *Mus musculus* can be distinguished from most other Egyptian mice by small size; lack of contrasting head, side and rump markings; and tail lacking a brush.

Habitats and ecology: It inhabits houses, tents, grain stores, gardens and salty areas. Nocturnal species. Burrows is shallow and usually under shrubs.

Status: Lower Risk (least concern).

Remarks: The colour of the specimens captured during the survey of Basuony (2003) is black when compared with the same species in other localities. Four individuals are captured from one burrow in Deshimi islet with insect remaining.

Family Canidae

13- *Acomys cahirinus* (Desmarest, 1819)

Common names: Cairro spiny mouse; **فار أبو شوك**

World distribution: North Africa from Mauritana to Egypt south to Nigeria east to Tenzania. Middle East and north to Turkey, Cyprus and Crete. Also Arabia and east to Iran and Pakistan.

National distrbution: Nile Delta and Valley, Alexandria, Western and Eastern Deserts, Sinai, shores of Lake Nasser, Gebel Elba, Oases of Western Desert and Gebel Uweinat.

Description: Small to medium-sized mouse. Coulor very variable ranging from uniform dark grey with white feet in Nile Delta and Valley to pale brown above, tinged orange along flanks, white below with pale limbs and white feet in desert populations, with many variations in between. Fur from behind the shoulder along back to tail base spiny. Ears large, whitish and eyes prominent. Tail about length of body, brownish above, pale below, sparsely haired with scales distinct.

Habitats and ecology: It is found in a wide range of habitats. In Nile Delta and Valley often in human settlements, including towns, cities, villages, tombs and grain stores. In deserts, it found in rocky wadis, cliff sides and palm groves. Active by day and night, though probably predominantly nocturnal.

Status: Lower Risk (least concern).

Remarks: There are 6 subspecies occurring in Egypt: *Acomys cahirinus cahirinus, Acomys cahirinus dimidiatus, Acomys cahirinus megalodus, Acomys cahirinus hunteri, Acomys cahirinus helmyi* and *Acomys cahirinus viator.*

***14- Canis aureus* Linnaeus, 1758**

Common names: Jackal; ديب – ابن آوى

World distribution: Southeastern Europe through Asia Minor and southern USSR to Iran, India, Burma, Thailand, Africa from Senegal to Egypt, south to Sudan, Ethiopia and Kenya.

National distrbution: Sinai, northern part of eastern desert, Nile Delta and Valley and bordering deserts, western Mediterranean coastal desert and oases of western desert.

Burullus observation sites: El-Tolombat by verbal locals.

Description: Dog-like carnivore with broad dorsal mane. Agouti nature of hairs on hip gives an impression of broken stripes. Side is yellowish with scattering of black- and white-tipped hairs. There is black marking on anterior of forelimb. Tail is relatively short with black tip. Pupil of eye is rounded. Frontal region of skull is inflated and cranial ridges are high and prominent.

Comparison: *Canis aureus* is distinguishable from other Egyptian canids in having the dorsum blackish and maned, frontal region of skull elevated, a prominent postorbital swelling, cranium broadest at bases of zygomatic processes and larger dimensions.

Habitats and ecology: Along the rivers and cultivated lands. Frequently seen in isolated cliffs and rocky hillocks in semi-barren desert. Nocturnal scavenger. Their dens are found in tombs, natural caves and crevices.

Status: Threatened (Vulnerable species).

Remarks: This species has not been recorded from Nile Delta. Their scavenging habits frequently render them a nuisance in the vicinity of human settlements, and they are often killed with poisoned baits, a practice that is seriously threatening their survival. Attacks of humans are rare, but not unknown (Harrison and Bates 1991). There appears to be no evidence to support the view of Flower (1932) that the large Egyptian race *Canis aureus lupaster* occurs in Palestine and recent studies suggest that this form is in fact a wolf (Ferguson 1981)

***15- Vulpes vulpes* (Linnaeus, 1758)**

Common names: Red Fox; ثعلب – ابو حصين

World distribution: Europe and continental Asia, northern India, peninsular Indo-China, Japan, Palaearctic Africa and North America.

National distrbution: Sinai, northern part of eastern desert, Nile Delta and Valley and western Mediterranean coastal desert.

Burullus observation sites: Coastal plain from El-Burg to Masstrooh and tracks seen in the islets of the lake.

Description: Large reddish fox. The dorsal surface is reddish to reddish brown; side is yellowish gray and venter is brownish or blackish. Tail is long, bushy and club-shaped with white tip. Ear is relatively large and

black posteriorly. Pupil of eye is elongate vertically. Skull is broadest on sides, narrower at base and frontal region is not inflated.

Comparison: *Vulpes vulpes* differs from other Egyptian foxes by darker colour, back of ear being black instead of pale brown in *V. rueppelli*, venter blackish and presence of black mark on foreleg.

Habitats and ecology: Inhabits date and fruit groves, cultivated areas and suburban gardens. Not strictly nocturnal. Commonly seen during daylight hours. Feeds on birds, rodents and insects (Basuony 1998).

Status: Lower Risk (least concern).

Remarks: According to Osborn and Helmy (1980) this fox is belonging to subspecies *aegyptiaca* that widespread in Nile Delta and Valley.

Family Mustelidae

16- Mustela nivalis Linnaeus, 1766

Common names: Weasel; **عرسة - ابن عرس**

World distribution: Europe, North America, northern Asia south to Asia Minor. In Africa, Morocco, Algeria and Egypt.

National distrbution: It is restricted to Nile Delta from Port Said to Alexandria south to Cairo and also in Faiyum.

Description: A very small, slender carnivore, males cosistently larger than females. Long-bodied and short-legged. Head relatively small, snout broad and ears small. Upper parts, legs, feet and tail chest-nut to dark brown. Under parts including chin and throat, white to cream, which may or may not clearly demarcated from the upper parts. Sometimes show brown spots or blotches on the underside. Tail around one-quarter of total length, slender, not bushy, brown above and below, slightly darker at tip.

Habitats and ecology: Largely a commensal of humans found in cities, towns, villages and agricultural land. Largely nocturnal, but can be seen during the day.

Status: Lower Risk (least concern).

Remarks: It has been suggested that the Weasel is introduced species. The fact that the lower Egyptian Weasel is considered sufficiently distinct to warrant subspecific status would suggest that the Weasel is native.

Family Viverridae

17- Herpestes ichneumon ichneumon (Linnaeus, 1758)

Common names: Egyptian Mongoose; **نمس**

World distribution: Africa, from Morocco and Egypt in the north to Cape Province in the south, Spain, Portugal and Turkey.

National distrbution: Nile Delta, Nile Valley south to Assyut, El-Faiyum and Burg El-Arab.

Burullus observation sites: Al- Kawm Al-Akhdar Islet.

Description: Weasel-like carnivore. Body is elongated. Pelage is long, coarse with blackish brown grizzled. Tail is long and tapering with black tip and flattened base. Palm and sole are naked. Claws are noncontractile. Ear is short, broad and rounded. Skull is elongated and broadest at the base of zygomatic process.

Comparison: *Herpestes ichneumon* is distinguishable from all other Egyptian carnivores by its speckled colouring; long and tapering tail; short and broad ears; high and narrow skull.

Habitats and ecology: Cultivated areas of Nile Valley and Delta, near water. Terrestrial species, but readily enters water and swims well. Diurnal and crepuscular. Feeds on rodents, birds, poultry, reptiles, frogs and various aquatic and terrestrial invertebrates (Harrison and Bates 1991). It is hunt their prey by speculation and tend to take a variety of species (Cloudsley- Tompson 1996).

Status: Lower Risk (least concern).

Remarks: The only specimen was seen as jumping from the islet land to reedbed through water canal.

Family Felidae

***18- Felis chaus nilotica* De Winton, 1898**

Common names: Jungle or Swamp Cat; **قط بري**

World distribution: Egypt through to Asia Minor, eastern Transcucasia, north along the west shore of the Caspian Sea to the Volga Delta, Iran, Afganistan, Chinese Turkestan, India, Sri Lanka, Burma and Vitnam.

National distrbution: Nile Delta, Nile Valley south to Aswan, El-Faiyum, Farafra and Dakhla oases and western Mediteranean coastal desert.

Burullus observation sites: Al-Kawm Al-Akhdar Islet.

Description: Large cat, colour is dark, and grizzled is buff. Lacrimal stripe is dark brown and prominent. Chick stripe is absent. Ear is reddish brown with black tip and small tuft. Tail is relatively short (one-third head and body length) with several black distal rings and black tip. Skull is large and condyloincisive length over 95 mm.

Comparison: *Felis chaus* can be distinguished from other Egyptian felids by less conspicuous body markings; cheek stripe lacking; black ear tufts; tail shorter and skull more elongate.

Habitats and ecology: Low cultivated or marshly ground, reed beds or any similar thick cover (Anderson 1902, Flower 1932, Osborn and Helmy 1980). Basuony (2003) saw an individual in reed swamp (*Phragmites australis*). It is primarily diurnal. Its diet consists principally of birds, small mammals, frogs and snakes of the genus *Coluber* and *Psammophis* (Harrison and Bates 1991).

Status: Vulnerable.

Remarks: The previous record of *Felis chaus* from Egyptian desert is from western desert, Nile Valley and southern corner of Nile Delta (Saleh 1993). The record of the study of Basuony (2003) added new geographical record of this species.

13.5. SUMMARY

A total of eighteen mammalian species, representing eleven families belonging to four orders, were recorded from Burullus Wetland. Rodents form the largest mammalian group of the area, being represented by seven species (about one-third of the total recorded species). Carnivores come next with five species. Insectivores and chiropterans were represented by only three species each.

Flower's Shrew *Crocidura floweri* is the only endemic mammal species known from Burullus Protected Area. The species is confined to the Egyptian Nile Valley, where it is very rare. The species was previously recorded from Wadi El Natrun in 1985. The only known record from Burullus area (Baltim) was from the 1930's. The Giant Musk Shrew *Crocidura flavescens* is the second rarest mammal in the Protected Area, where it is scarce. Three rodents are widely considered as pests because of the damage they cause to crops, these are: Black Rat *Rattus rattus*, Brown Rate *Rattus norvegicus* and House Mouse *Mus musculus*.

There are no globally endangered mammalian species recorded in Burullus Protected Area. In addition to the endemic Flower's Shrew *Crocidura floweri*, the Jackal *Canis aureus* and Jungle Cat *Felis chaus* are locally threatened large carnivores.

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13.7. PLATES OF MAMMALS (13.1 – 13.9)

(after Wassif 1995, Websites: www.animals.net & www.iucn.org)

Plate 13.1
Hemiechinus auritus
Crocidura flavescens

Plate 13.2
Crocidura floweri
Rousettus aegyptiacus

Plate 13.3
Rhinopoma microphyllum
Pipistrellus kuhlii

Plate 13.4
Gerbillus andersoni
Psammomys obesus

Plate 13.5
Arvicanthis niloticus
Rattus rattus

Plate 13.6
Rattus norvegicus
Mus musculus

Plate 13.7
Acomys cahirinus
Canis aureus

Plate 13.8
Vulpes vulpes
Mustela nivalis

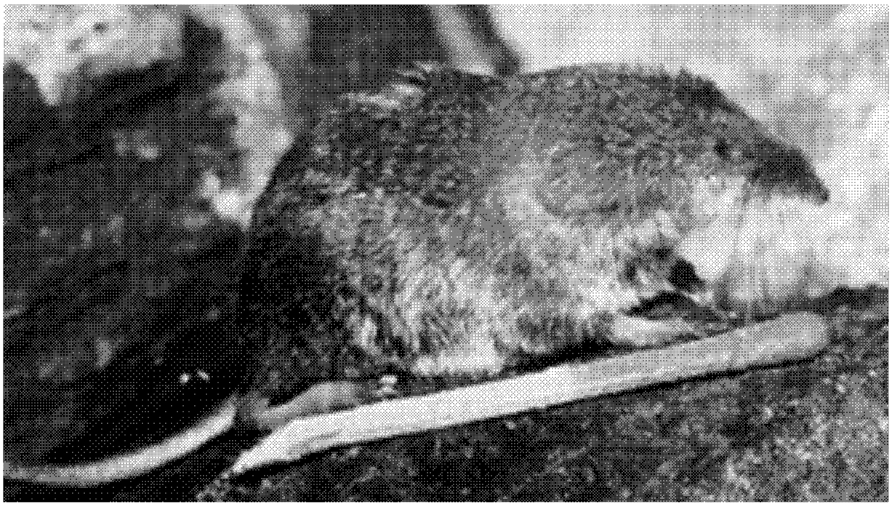
Plate 13.9
Herpestes ichneumon
Felis chaus

Plate 13.1

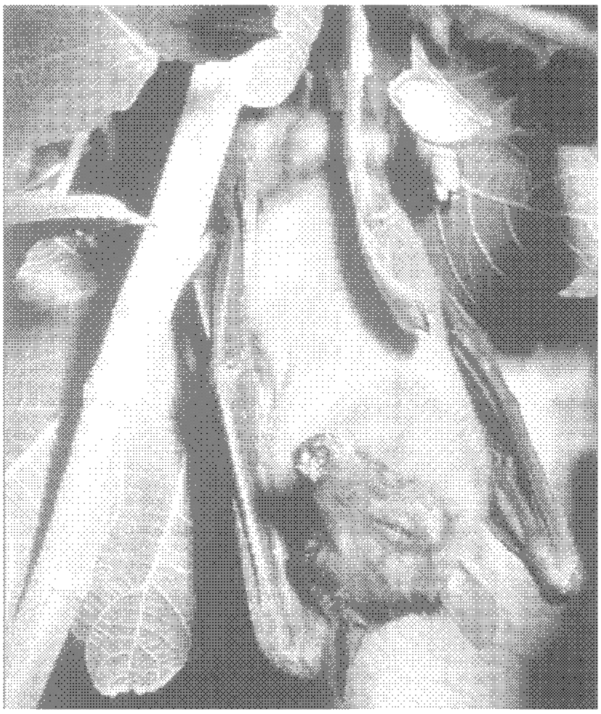
Hemiechinus auritus قنفذ طويل الأذن

Crocidura flavescens زباب عملاق

Plate 13.2



Crocidura floweri زباب الزهور



Rousettus aegyptiacus خفاش الفاكهة المصرى

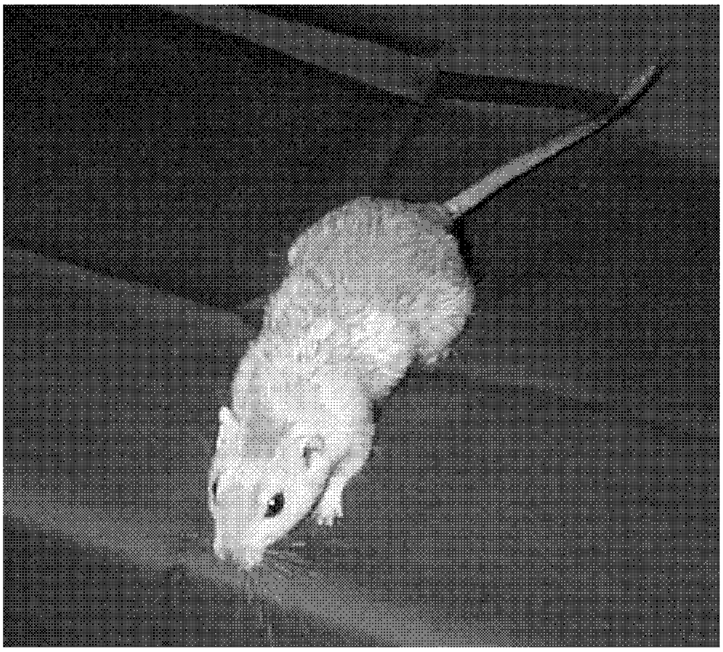
Plate 13.3

Rhinopoma microphyllum أبو ديل الكبير

Pipistrellus kuhlii خفاش كولى

Plate 13.4

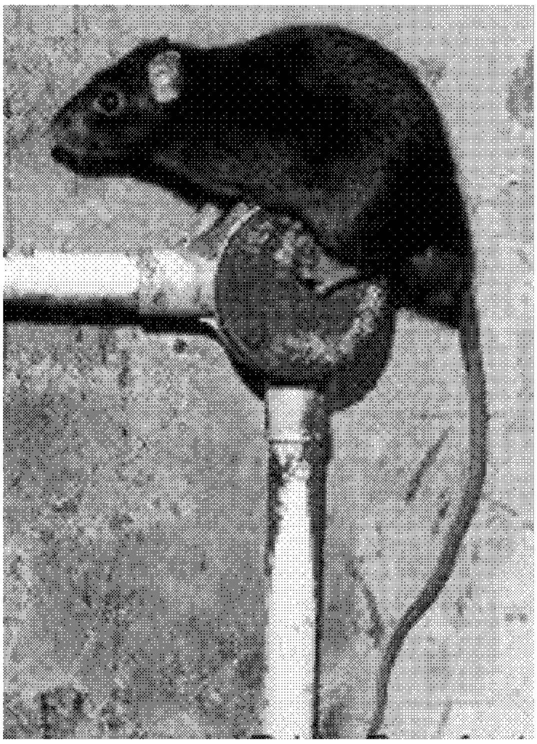
Gerbillus andersoni بيوضى



Psammomys obesus جرد

Plate 13.5

Arvicanthis niloticus فأر الغيط



Rattus rattus جرذ اسود – جرذ المنزل

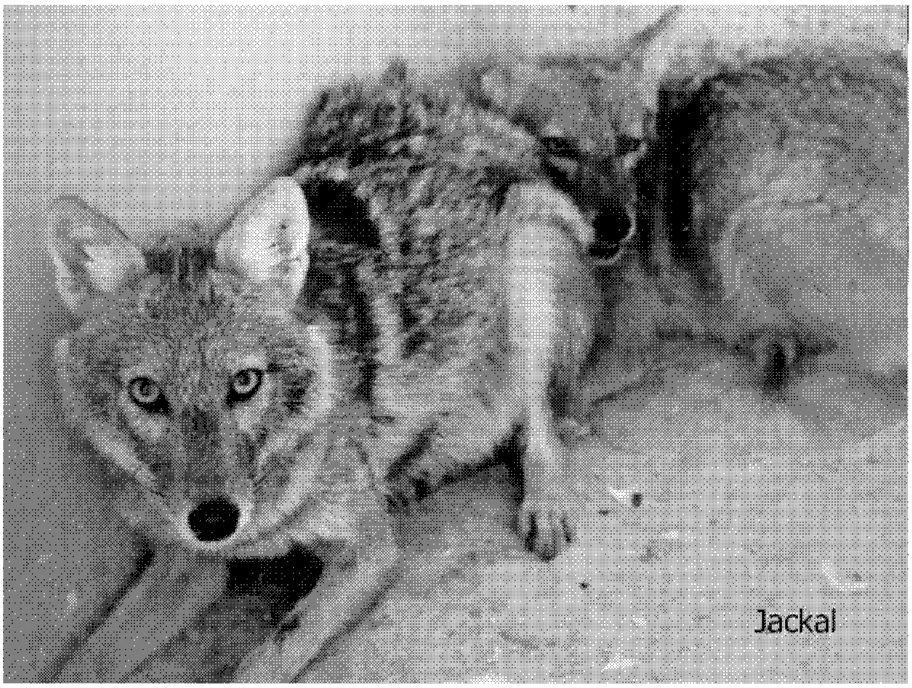
Plate 13.6

Rattus norvegicus جرذ نرويجى

Mus musculus فأر المنزل

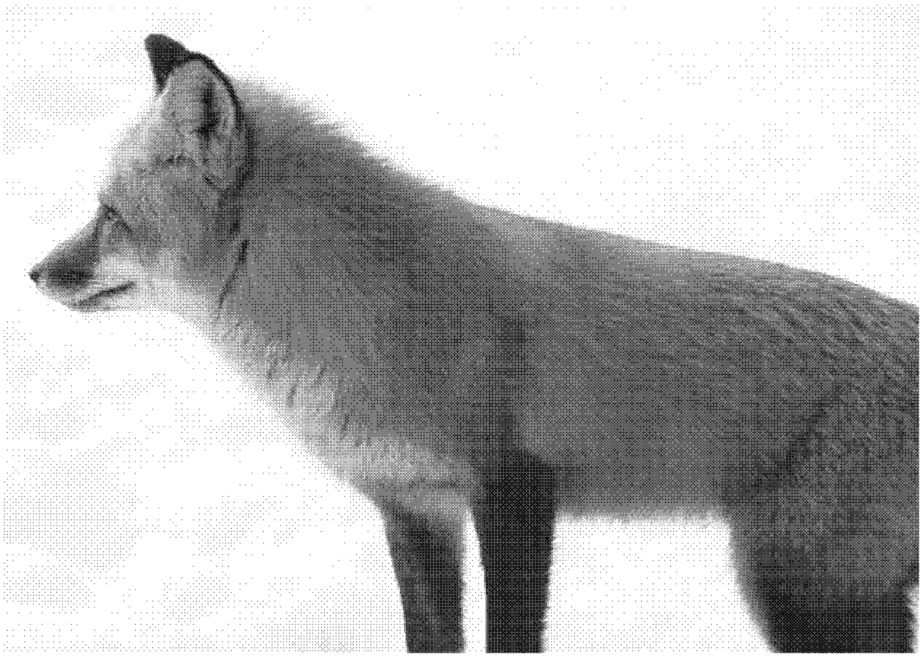
Plate 13.7

Acomys cahirinus فأر ابو شوك القاهرى



Canis aureus ابن آوى

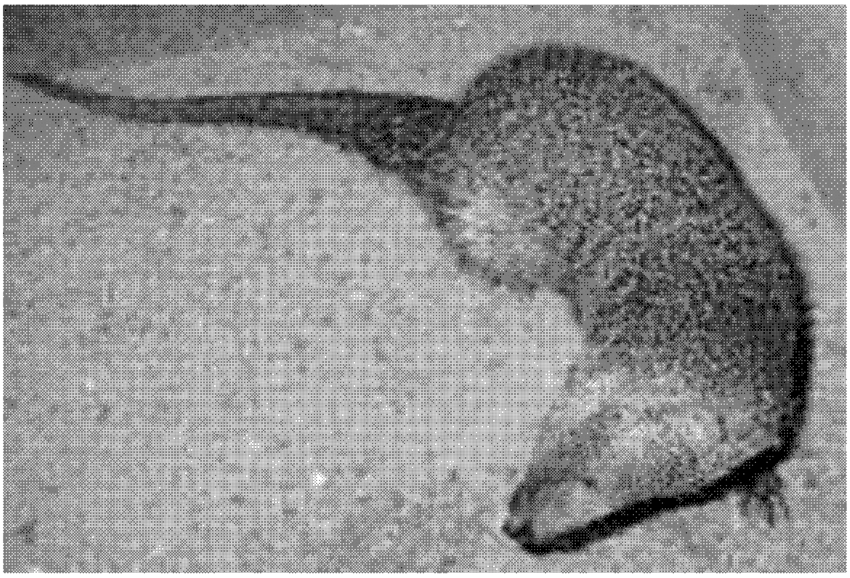
Plate 13.8



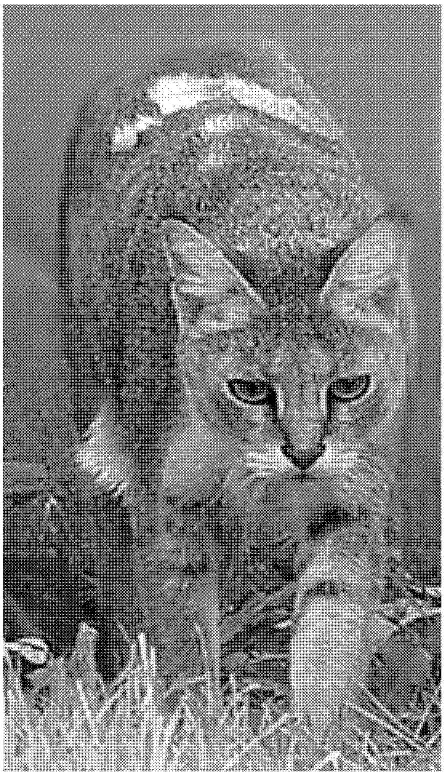
Vulpes vulpes ثعلب أحمر

Mustela nivalis ابن عرس (عرسة)

Plate 13.9



Herpestes ichneumon نمس مصرى



Felis chaus قط برى نيلى

Chapter 14
Socioeconomic features

Experience during recent decades asserted that efforts carried out to preserve natural protected areas could culminate with success when taking the human element into consideration, as well as attracting inhabitants of protected areas to effectively participate in plans undertaken for development and conservation of the natural environment of such areas. This needs to be based on raising awareness of inhabitants, and linking their direct everyday life interests and preserving the natural elements available in the protected areas; and requires the studying of the prevailing economic and social characteristics in protected areas. In this regard, Shaker *et al.* (2000) conducted a study at Burullus Wetland, aiming at identifying the prevailing economic, social and institutional characteristics in villages and different districts of Burullus Wetland, to introduce diagnostic analysis for human-environment interface and to identify the core problems faced by inhabitants to be taken into consideration in development of area planning.

14.1. DEMOGRAPHIC ESTIMATION

Lake Burullus is located in Kafr El Sheikh Governorate, one of the largest Governorates in Nile Delta. This Governorate is located along 100 km of the Mediterranean coast in north Egypt. It borders to the west with 85 km of the Rosetta western Nile Delta arm, to the south with Gharbia Governorate and to the east with Dakahlia Governorate. Kafr El Sheikh is mainly an agricultural Governorate with a total population of 2319063 person (census of 1999): 1053173 females and 1265890 males (Table 14.1). The majority of the population (77.1 %) lives in the rural areas, which reflects the agricultural nature of the Governorate. It covers a total area of 3748 km^2 (892204 Feddan).The agricultural cultivated area forms 62.1% (554237 Feddan) of the total area of the

Governorate (Table 14.2). This Governorate is also leading in average production yields in comparison with the average total of Egypt. It produces rice, wheat, cotton, maize, sugar beet and potatoes. The Delta sugar beet factory in El-Hamoul is the biggest that extracts sugar from sugar beet.

Table 14.1. **Human population and gender in urban and rural areas in Kafr El-Sheikh Governorate (Anonymous 1999).**

Population	Male		Female		Total		Growth rate (%)
	Actual	%	Actual	%	Actual	%	
Urban	366271	50.1	164994	49.9	531265	22.9	1.8
Rural	899619	50.3	88179	49.7	1787798	77.1	3.1
Total	**1265890**	**50.2**	**1053173**	**49.8**	**2319063**	**100**	**2.1**

Table 14.2. **Total area and population density (person km^{-2}) in Kafr El-Sheikh Governorate (Anonymous 1999).**

Area	km²	Feddan	Percentage (%)	Density (person km^{-2})
Urban	1419.7	337966.9	37.9	374.2
Rural	2328.3	554237.0	62.1	767.6
Total area	**3748**	**892203.9**	**100**	**618.7**

The human to agricultural land ratio in the Governorate is 0.24 Feddan per person, which is higher than the Egypt's average of only 0.11. This means that there are, in average, four persons per Feddan in comparison with the Egyptian average of ten persons per Feddan. This Governorate is also known for its animal husbandry projects and fish production especially from Lake Burullus. The Governorate has ten Districts with ten cities, 205 villages and 1695 farmsteads, which reflect the rural nature of the Governorate.

The total unemployment figures in the Governorate (67200 person) equals 9.6% of the total workforce (Table 14.3). The unemployment rate of 12.0% of the workforce in the rural areas is higher than the urban areas of only 5.5%. There is a good opportunity to absorb these unemployed persons in rural areas, because of the agricultural nature of the Governorate. The cultivated area now forms 62.1 % of the total area. There is still 49200 Feddan of reclaimable land in the Governorate that can absorb the unemployed people in the rural sector.

Table 14.3. **Employment conditions in Kafr El-Sheikh Governorate (Anonymous 1999).**

Population	Employed person	Unemployed person	Total workforce	Unemployment rate (%)
Urban	249000	14600	263600	5.5
Rural	386000	52600	438600	12.0
Total	**635000**	**67200**	**702200**	**9.6**

A ministerial Decree Nr. 1770 in 1997 planned the creation of two industrial areas, the first covers 114 Feddans in Baltim, and the second covers 1160 Feddan along the international coastal road in Metobes.

14.2. SOCIAL CHARACTERISTICS

14.2.1. Ethnologic Morphology

14.2.1.1. Communities and Villages around Lake Burullus

Lake Burullus is located within five districts of Kafr El Sheikh Governorate. These Districts, from the east to the west, are Baltim, El-Hamoul, El-Riad, Sidi Salem and Metobes (Fig. 14.1). The main activities of the population in and around the lake are fishing, reed cutting, grazing and agriculture. The total population number in the five districts is 965220 persons which approximates 41.6 % of total population of Kafr El-Sheikh Governorate (Table 14.4).

14.2.1.2. Communities within the Burullus Protected Area

The Baltim district has the biggest population concentration especially in Baltim city which has the highest population density of 707 person km^{-2} (Table 14.4); it is even higher than the Governorate average of 618 person km^{-2}. The biggest population concentration in Baltim District is in Baltim City and Burg El-Burullus Village (50.8%) which are close to the lake. Although the cultivated area in the five districts forms 52.8% (554237 Feddan) of the total cultivated area of the Governorate, and has 42.6% of the all tenants, still the majority are fishermen in most the villages and cities surrounding the lake. Average land tenure in the five districts is about three Feddan per tenant (Table 14.5), which could mean that the agricultural activities are the principal economic activity, but in fact fishing activity is also dominant.

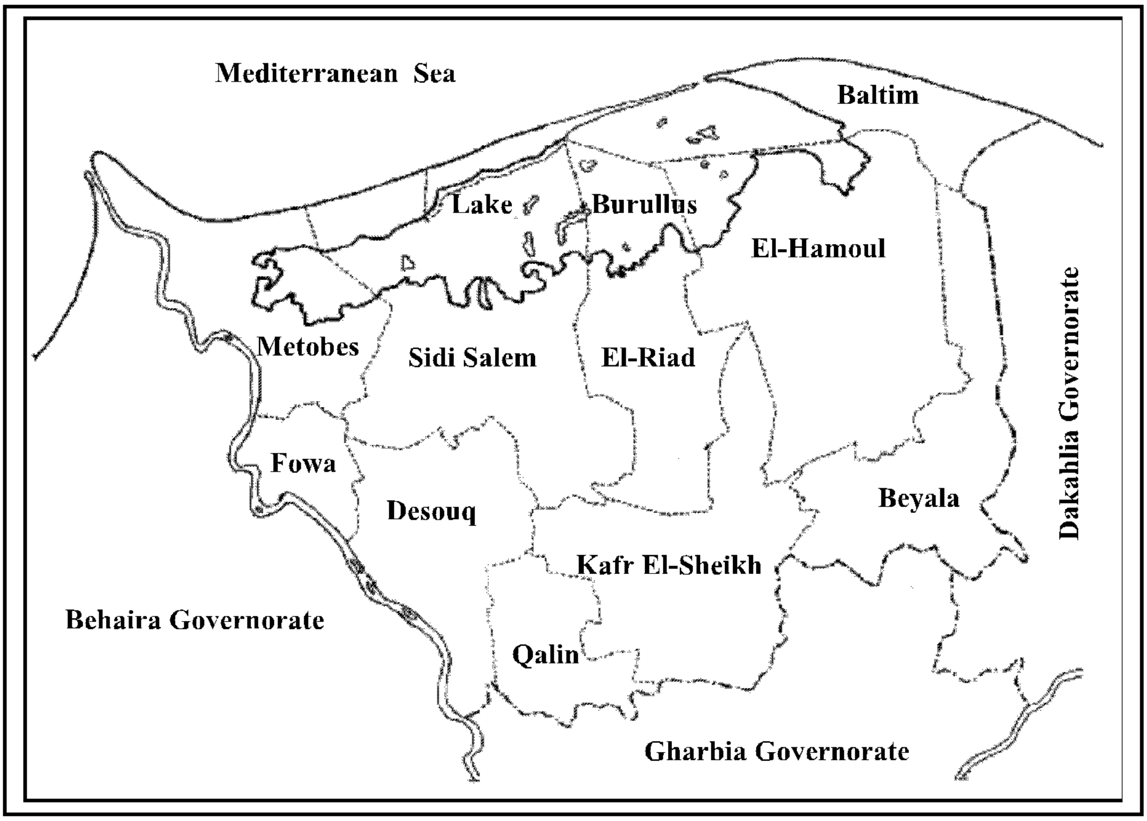


Fig. 14.1. **Map showing the five districts surrounding Lake Burullus.**

Table 14.4. **Population distribution in the five districts around Lake Burullus (Anonymous 1999).**

District	Population Count		Density (person km^{-2})	Growth rate (%)
	Actual	%		
Metobes	195040	20.2	597	2.4
El-Hamoul	206580	21.4	254	2.1
Baltim	145270	15.1	707	2.4
El-Riad	126820	13.1	334	2.5
Sidi Salem	291510	30.2	427	2.3
Total	**965220**	**100**	--	--

Table14.5. **Agricultural area in the five districts surrounding Lake Burullus (Anonymous 2000).**

District	Number of agricultural tenants	Total cultivated area (Feddan)	Land tenure (Feddan tenant $^{-1}$)
Metobes	14927	40759	2.7
El-Hamoul	18570	91129	4.9
Baltim	6727	29061	4.3
El-Riad	17750	46276	2.6
Sidi-Salem	35720	58194	1.6
Total	**93694**	**292419**	**3.1**

14.2.2. Social Organization

The existence of the social organizations depends mainly on the conscious and educational status of the population as well as the number of problems facing the population in their main economic activity providing their income. Therefore the most important organization is the fishermen's cooperative, then agricultural cooperative and the community development organization.

One of the important indications was that 47 % of the selected sample of Burullus population were illiterate, 42% could read and write and 8% had at least a high school level (vocational school). None of the respondents had higher education. The illiteracy rate of the respondents family members was less than that of their parents, 31% of them had four years of school education, 28% had up to six years of school education, and 20% had twelve years of school education, 5% had no school education at all and the rest (16%) could read and write. Note the relatively old age of the respondents (52% over 55 years old, 43% were from 36 – 55 years old and 5% were from 25 - 35 years old).

The average family size is six to eight members (51%), and 17% have a family of nine person. The interaction of the family size and the affinity of family members towards education is significant, education improves awareness which could promote the environmental consciousness.

From the field study, it has been noticed that fishing, livestock, bird catching, cultivation in addition to cutting and marketing of reeds are the main common activities in Burullus Wetland. In applying some economic indicators, the following results could be concluded: the questionnaire revealed that 79% of the respondents were members in fishermen cooperatives and 21% were not-members. The cooperative members stated that fishermen cooperative renders some services to them such as: 1- rendering fishing requirements on credit, 2- issuing licenses for fishermen and boats, 3- solving problems of fishermen with the local authorities, and 4- collecting fees from fishermen.

14.2.3. Social Services

The social services institutions inside the protected area are very limited around the lake and concentrated mainly in Baltim District. The local infrastructure cannot provide sufficient support for the overpopulated region. In Burullus villages there are some social services such as: 1- health service unit, 2- ambulance unit, 3- police station, 4- agricultural cooperative, 5- village bank, 6- primary and preparatory schools, 7- youth centre, 8- veterinary service unit, and 9- post office. There are also drinking water and electrisity. There is no hygiene (sewage) system, as they use the traditional system (under ground container that is emptied periodically). There is 366 km of paved roads in the surveyed villages. There is also an international coastal road along the northern coast of the lake and the Mediterranean coast. The public transport facilities include 44 taxies (microbuses), and around 55 horse carts. There is no railway connection, but only a bus-line conecction between Baltim and Kafr El-Shiekh.

14.2.4. Social Categories

Fishing is considered the main activity in the Burullus Protected Area. Most of the population consists of fishermen, farmers, fish merchants and fish brokers. Asking the fishermen who have sons practicing fishing, revealed that about 54.2 % of them have one son, 37.3 % have two sons and 8 % have three and more sons working in fishing. These results indicated that sons of some fishermen gave up fishing, the matter that may be attributed to their tendency to education and working in governmental occupations probably due to the relatively low fishing income in Lake Burullus.

14.2.5. Values and Needs Expressed by the Inhabitants

Considering that fishing is the common activity of the Burullus population, identification of problems and urgent solutions should be considered to fulfill the requirements of biodiversity conservation and protection measures. In asking the respondents about problems facing them, these can be descendently ordered as follows (after Shaker *et al.* 2000):

1- The profession risk, for instance illness and early old age, where they practice fishing under hard climatic conditions (85%).

2- Neglect of the sea inlet (Boughaz) and the Brimball Canal led to the reed growth in the lake and consequently the decrease of its productivity (83%)

3- The relatively low and limited daily income of fishing (80%).

4- Pollution of lake water due to the sewage and agricultural drainage (78%).

5- Low productivity of fish can be attributed to the illegal harvesting of fish fry and selling it to the fish farm owners at high price (68%).

6- Overcharging the taxes that are randomly estimated, and not based on real data about the fish production (67%).

7- Limited effectiveness of the water-surface police in enforcing law (59%).

8- Spread of reeds, rats and mosquitoes (47%).

9- Absence of disablement pension and health insurance for fishermen (43%).

10- The monopolistic power of merchants under the existing marketing channels with the absence of the cooperative role in marketing fish (41%).

11- The retirement pension (LE 75) is too low to satisfy basic needs (35%).

12- Absence of a governmental authority, which seeks to solve their problems (31%).

13- Inability of fishermen cooperatives to perform their responsibilities, this weakens the solidarity among members and their cooperatives (21%).

No doubt that the existing role of cooperatives in confined to supply members with some fishing requirements and to renew licenses. Moreover, some members stated that prices of these requirements are high. Finally the fishermen expressed their inability to practice any other profession. By asking the fishermen about the likely means to solve the problems they mentioned the following proposals:

1- Cleaning the sea inlet (Boughaz) and opening Brimbal Canal to enhance the flow of seawater and to increase the fish production of the lake (33%).

2- Expanding the health insurance umbrella to cover fishermen (78%).

3- Stopping sewage and agricultural drainage into the lake, where pollution of lake water adversely affected the fish productivity and human health (65%).

4- Banning illegal harvesting of fish fry from the sea inlet to increase fish production of the lake and consequently increase the fishermen income (61%).

5- Partial removing of reeds and other water plants hindering fishing in the lake (57%).

6- Reconsidering the taxation system that should be based on the actual fish production, under the existing low production, taxes seem to be in too high (54%).

7- Necessity of insurance services for fishermen against the profession risks (47%).

8- Supplying fishermen with loans specially in emergencies and crisis (43%).

9- The role of water-surface police should be concentrated on banning illegal fishing with reference to fishing spawn and fishing gears (39%).

10- Reducing retirement age of fishermen to 60 year instead of 65 year (35%), and raising the retirement pension (29%).

11- Establishment of a police center at the opening of the sea inlet under the bridge of the international coastal road to stop fry stealing (31%).

12- Improving the role of fishermen cooperatives through supporting their financial status (27%), cooperatives should help their members in marketing their production.

13- Raising the wages of fishermen employed on boats.

14- Banning fishing in the lake for at least two month every year to allow for the growth and reproduction of fish.

15- Creating alternative livelihoods for fishermen especially during the period of banning fishing.

16- Opening a new sea inlet at the west of the old inlet (10 km), to feed the lake with seawater.

14.3. ACTIVITIES AND IMPACTS

14.3.1. Land Use in the Catchment Area

Land use in the catchment area has notable influence on the natural status and the water quality of Lake Burullus. The drainage canals carry diverse wastes, pesticides, and fertilizers into the lake. These inflows are not filtered before entering the lake and therefore contaminate the lake. Furthermore the catchment area stretches far beyond the boarders of the Governorate.

14.3.2. Land Uses in the Study Area

14.3.2.1. Tourist activity

Kafr El-Sheikh Governorate has six historical sites such as the prehistoric City of Butu, known now as Tal Elpharaeen, and also some Islamic sites still to be excavated from beneath the sand dunes, beside the recreation sea resorts. In addition, 25000 Feddan on the northern Sandbar are proposed for tourism development. Nevertheless the Governorate has little touristic potentiality. Although the statistics about hotels, tourist resorts and rooms are contradictory. Even with some recreation areas as Baltim and Lake Burullus, there are a total of 164 hotel rooms in the Governorate. This number differs from one source to another and does not reflect the real touristic potentiality of the Governorate.

14.3.2.2. Agricultural activity

There are apparently little agricultural activities in a zone of 1 to 2 km south of the southern shore of the lake. The demarcation between farming and bare land (salt marshes) seems clear. In the southeast, there is a distance between the lakeshore and agricultural activities, although some scattered farms exist. In the last decade there had been development of fish farms especially along this shore, and today the main activities consist of the construction of many ponds for various fish types.

The area near Baltim is intensively cultivated, mainly with date palms. There is a tendency to create further fish farms because their economic output per Feddan is much higher than any agricultural productivity. It should be noted that a combination of the two products could raise the total economic output.

Because of new reclamation efforts in the wasteland, the Government decided to establish El-Zawia fish farm in 1980's. Since then, this fish farm is quite successful except for the fact that it has been operating at half of its capacity. The shortage of clean water in the mid Delta does not only affects El-Zawia fish farm, but also affects many of the private fish farms in the area as well as the agricultural farms.

Landsat satellite passed over Lake Burullus in 1973 and 1979 have provided images, which show the extent of natural plant cover in the lake region. No agricultural activity is apparent for some 4-5 km south of the southern shores, and the demarcation between farming and bare land in the southwest is very clear. In the southeast, there was greater distance between the lakeshore and agricultural activity, although some scattered farms exist. The area near Baltim was intensively, cultivated mainly in date palms.

The experience of El-Hamoul Scheme (a large government reclamation project in the southern and eastern regions of Burullus initiated in 1956) showed that some problems were faced by development and reclamation projects. By 1960, El-Hamoul Scheme had had reclaimed about 2500 Feddan in Helmea zone, situated between Bahr Tira and Gharbia drains. By mid 1972, a total of 70100 Feddan had been reclaimed, of which 30800 were farmed as a state farm, while 31700 Feddan were distributed to 7518 families, giving an average holding size of 4.2 Feddan per family. By 1979, 23 years after the project was begun, some 70000 Feddan had been distributed to 13412 settlers, some 8900 Feddan, had been sold at auction, and 48500 Feddan had been leased to the Delta Sugar Company at El-Hamoul.

According to El-Hamoul Scheme management, only about 50% of the distributed land had achieved marginality in 1979. One survey in the summer of 1977 in Hafr Shehab, part of the reclaimed area east of Burullus, found that settlers farmed a total of 41000 Feddan, of which only 68% was under crops.

Furthermore, they achieved about 60% of the national average yield of rice and less than 40% of the national average yield of cotton. These are poor yields for lands, which have been in the process of reclamation for 15-20 years.

Economics of agricultural crops are not very profitable. The only profitable crops are guava, berseem and dates. Net return per Feddan and net return per pound of costs have been estimated for the main crops (after Shaker *et al.* 2000). Based on the criterion of profitability per cost unit, it can be summarized that guava, berseem (alpha alpha) and dates are considered the most valuable and profitable crops in comparison with the other agricultural crop types (Table 14.6).

***Table 14.6.* Net return of the main crops at the sample level in Burullus Wetland (Shaker *et al.* 2000).**

Crop	Sample area (Feddan)	Gross return	Total cost	Net return	Net return per Feddan	Net return per pound of cost
		LE				
Winter tomatoes	1.5	6200	2500	3700	2467	1.5
Cabbage	4.8	11650	3650	8000	1053	2.2
Cauliflower	2.5	10050	3400	6650	1547	2.0
Beans	1.5	2000	1050	950	633	0.9
Berseem	3.0	3420	650	2770	923	4.3
Wheat	2.0	3550	1375	2175	1088	1.6
Rice	8.0	13300	4400	8900	1113	2.0
Maize	7.0	5900	2500	3400	486	1.4
Summer tomatoes	10.3	45400	13000	32400	3146	2.5
Dates	5.1	8900	1890	7005	1387	3.7
Guava	14.6	59750	9750	50000	3436	5.1

14.3.2.3. Fisheries

With about 31% of the area of Delta lakes, Lake Burullus produced only about 21% of the landed fish tonnage in all the Delta lakes during 1970-77 period. In 1977, Burullus produced almost 6587 ton of fish valued at about LE 3.4 million. Approximately 8500 licensed fishermen in 1977 produced an average of 772 kg each, with an average value per fisherman of about LE 398. During the period 1970-77, the average net income per fisherman was LE 368, almost twice that of Edku, but only 31% of that of Maryut and 29% of that in Manzala.

Lake Burullus had the most productive mullet fishery of the Delta lakes due to the wide lake-sea connection, which allows high recruitment of mullet fry from the sea each year. The mullet grows to be many times the size of tilapia

and are valued at several times the price of the common species. The warm, shallow waters and large amounts of organic materials available for food form ideal grounds for mullet fry to develop, particularly in the calm area, near the shores and around the islands. But due to the fact that the water of the lake is becoming increasingly fresh water, the amount of the mullet has decreased in the last decades. Throughout the 1960's and 1970's the production of mullets of Lake Burullus was higher than the other lakes.

In 1977, there were approximately 8500 licensed fishermen working on the lake, 4400 fishermen are registered in El-Burg fishermen cooperative alone. The fishermen stated that there is about double this number of illegal fishermen in the lake and they use the reed as cover from the Water Surface Police. Today there are around 3500 licensed boats on Burullus, entirely classed as third class boats. The boats on Burullus are larger than those of the other lakes. There are considerable numbers of large "markebs" and many intermediate sizes of "feloukas" as well as large size canoe-like boats. In the shallow areas the fishermen use wire traps for fishing especially in the shallow areas near some islands and along the shoreline, for this method they use various types of fishing nets.

Fishery performance in Lake Burullus is weak due to many factors. The main one is the new hydrological regime caused by the construction of High Aswan Dam, which deprived the lake of the annual flow of flood water and sediments, which were brought by the yearly floods. On the other hand, there has been an increase in the nutrient-rich drainage water flowing into the lake. Assessments of the impact of the new water regime on Lake Burullus concludes that the lake receives nutrient-rich sewage, which changes the water quality and leads to eutrophication (Reid and Rowntree 1982).

14.3.2.3.1. Fish productivity

The gross fish production fluctuated between a minimum limit of about 24274 ton in 1988 and a maximum limit of about 53000 ton in 1996. It decreased since then to 55000 tons in 1999, with a decreasing rate of about 6.9 % than that in 1996 (Table 14.7). See also chapter 9.

14.3.2.3.2. The relative importance of fish production

Fish production of Lake Burullus in 1988 accounted for about 22.3% and 8.7% of the northern lakes and national fish production, respectively. Then it accounted for 47.2 % of northern lakes in 1996, but dropped to 44.6% in 2002 (Table 14.8). Concerning the relative importance, its maximum limit of 17% of the national fish productivity was in 1990, afterwards it dropped again to about 7.4 % in 2002. As an average, Lake Burullus production accounted for 42 % and 12 % of the northern lakes and national fish production, respectively.

Generally it can be concluded that the gross production of Lake Burullus dropped in 2002.

Table 14.7. **Fish production and productivity of Lake Burullus during the period 1988-2002 (Anonymous 2002).**

Year	Gross production (x 1000 ton)	Area (x 1000 Feddan)	Number of boats	Productivity	
				kg/Fed.	kg/boat
1988	24.3	115.0	6612	231	4023
1989	41.9	114.3	6065	367	6908
1990	57.8	114.3	7125	506	8112
1991	51.8	114.3	7178	453	7216
1992	52.3	114.3	7323	458	7142
1993	48.0	110.0	6452	436	7440
1994	49.0	113.0	7407	488	7439
1995	53.0	116.0	7958	510	7439
1996	53.0	110.0	7971	540	7452
1997	53.0	104.0	7891	564	7439
1998	53.0	103.0	7931	573	7439
1999	55.3	103.0	6924	537	7987
2000	51.7	103.0	9624	501.9	7466
2001	59.2	103.0	8770	574.7	6750
2002	59.7	103.0	8770	579.6	6807

Table 14.8. **Lake Burullus fish production (1000 ton), and its relative importance to the national gross production and production of northern lakes (1988-2002).**

Year	National gross production	Production of northern lakes	Lake Burullus Production	% of gross national production	% of northern Lakes
	Per 1000 ton				
1988	306.9	119.2	24.3	8.7	22.3
1989	325.1	109.8	41.9	12.9	38.2
1990	339.4	131.5	57.8	17.0	44.0
1991	345.1	123.1	51.8	15.0	42.1
1992	347.5	122.8	52.3	15.1	42.6
1993	358.2	124.2	48.0	13.4	38.7
1994	368.4	127.6	49.0	15.0	43.2
1995	407.1	130.5	53.0	14.5	45.4
1996	431.5	125.9	53.0	13.8	47.2
1997	456.9	137.1	53.0	12.9	42.8
1998	545.6	152.1	53.0	10.8	38.8
1999	648.9	135.1	55.3	8.5	40.9
2000	724.4	141.2	51.7	7.1	36.6
2001	771.5	144.7	59.2	7.6	40.9
2002	801.5	133.8	59.7	7.4	44.6

14.3.2.3.3. Fishing income

By interviewing the fishermen (sample), it was observed that the common fishing gears were samboak, feloukas, and sailboats. The return on investment and net return had been estimated for the three fishing gears (Table 14.9). It is clear that the estimated rate of return on capital amounts to 22 %, 26 % and 30 % for samboak, felouka and sailboat, respectively.

***Table 14.9.* Return on investment (LE) in fishing gears in Lake Burullus (Shaker *et al.* 2000).**

Item	Samboak	Felouka	Sailboat
Capital cost (LE)			
Fishing boat	350	1200	16000
Fishing net	325	900	2100
Total capita cost	675	2100	18100
Fishing period (day)	150	150	300
Operating cost (LE)			
Fishing boat	100	300	3000
Fishing net	150	350	1500
Wages	1500	4000	36750
Miscellaneous	100	250	1000
Total operating cost	1850	4900	42250
Return (LE)			
Total return	4247	7700	50000
Net return for owner	2397	2800	7750
Cost for owner and manager	2250	2250	2250
Net return on capital	147	550	5500
Rate return on capital (%)	22	26	30
Monthly income for owner	342	400	1107

14.3.2.4. Livestock economics

It has been observed from the field study of Shaker *et al.* (2000) that the inhabitants breed buffaloes, cows, sheep and goats. Net return per animal unit and per capita has been estimated (Table 14.10). Buffaloes came first followed by cows, goats and sheep in a net return of about LE 2250, 1690, 989 and 865, respectively. The average net return per unit of livestock amounts to LE 1710. Therefore the per capita annual net return amounts to LE 421. Based on these results, it may be noted that the per-capita net income of livestock in this area seems to be relatively low. This may be attributed to the limited numbers of heads bred by each family on one hand, and the low productivity of these animal varieties on the other hand.

Table 14. 10. **Net return (LE year $^{-1}$) of livestock at the sample level in Lake Burullus. *: Represents the total animal units based on the head of buffaloes, cows, sheep and goats equals 1.1, 1.0, 0.2 and 0.16 animal unit, respectively (Shaker *et al.* 2000).**

Item	Buffalo	Cow	Sheep	Goat	Livestock
Herd size	8	11	17	13	25.3*
Gross return	23900	24600	35580	2695	54775
Total cost	4100	6000	640	680	11420
Net return	19800	18600	2940	2015	43255
Net return per head	2475	1691	173	155	---
Net return per animal unit	2250	1691	865	969	1710
Per family net return	---	---	---	---	2890
Per capita net return	---	---	---	---	421

14.3.2.5. Reed economics

It has been observed that reed plants grow in lake Burullus in an intensive way, the matter that adversely affects fish productivity. Therefore, the inhabitants of this area practice pasturing their animals on reed in the first stages of it growth. When the reeds reaches full maturity, it will be cut and sold at a market price of about LE 0.20 – 0.60 per bundle. Reed plants are used for thatching, crop protection against wind and for fishing nets and bird catching. Net return of cutting reed activities has been estimated (Table 14.11). It is indicated that per capita net return amounts to LE 118.8 in one season, on average about one Egyptian pound per day. It is apparent that this activities are not economically feasible. But if we take into consideration its importance as animal fodder over the years, reed could be refined as an important product.

Table 14.11. **Net return of cutting reeds (*Phragmites australis*) in Lake Burullus. *: Estimated on the following bases: number of observations = 100 family, period of cutting reeds =120 day year $^{-1}$ and average family size = 7 person (Shaker *et al.* 2000).**

Item	Return (LE season $^{-1}$)
Gross return	101190
Total return	18000
Net return	83190
Per family net return	831.9
Per capita net return	118.8*

14.3.2.6. Bird catching economics

Although bird catching is prohibited within the borders of Burullus Protected Area, this activity is considered one of the important sources especially in autumn. Net return of bird catching of three common species has

been estimated (Table 14.12). It can be concluded that net return per bird of quail (semman), LE 1.9, is relatively low in comparison with ghor and hamrawy (LE 9.4). This can be due to that the great number of semman catches during the season. In estimating per capita net return per day; it has been revealed that semman catching proved to be more profitable than other birds. Per capita net return gained from bird catching amounted LE 17.3 per day.

Table 14.12. **Net return of bird catching of three common species in lake Burullus. *: Amounted to about 55 days in autumn.**

Item		**Semman (quail)**	**Ghor (coot)**	**Hamrawy (pochard)**	**Total**
Number of birds caught		132110	23045	21175	176330
*Gross return**		272195	230450	211750	714395
Total cost	**LE season^{-1}**	20055	13910	12788	46753
Net return		252140	216540	198962	667642
Per bird net return (LE bird^{-1})		1.9	9.4	9.4	3.8
Per family net return (LE day^{-1})		45.8	39.4	36.2	121.4
Per capita net return (LE day^{-1})		6.5	5.6	5.2	17.3

14.4. SUMMARY

Kafr El Sheikh Governorate as a whole has a total population of 2319063 individuals (in 1999). Lake Burullus is located within five districts of the Governorate (from east to west: Baltim, El Hamoul, El Riad, Sidi Salem and Metobes), with a total population of 965220 individuals. Baltim district has the largest population around the Lake, mostly concentrated in Baltim city. The exact population number residing inside the Protected Area and their distribution is not yet known.

Fishing is the leading economic activity in the Protectorate and in Lake Burullus at large. Fish production from the Lake increased over the past two decades from just 7273 tons in 1982 to 53000 ton in 1996. It remains high with 55300 and 51768 ton in 1999 and 2000, respectively. The data on fish production for 2002 is about 59700 ton. The dramatic increase in the catch is the result of more intensive catching effort rather than a result of improved productivity. The catch composition clearly shifted from mainly marine species to fresh water species, particularly tilapia. In 1964 approximately 45% of the catch was tilapia, 25% shrimp and crab, 20% mullet and 10% catfish. This pattern changed in 1991 into nearly 75% tilapia, <10% shrimp and crab, 10% mullet and <10% catfish. In addition, the average size of the fish caught in the

Lake has declined. In 1992, about 65% of the total catch of tilapia was categorized as small, 25% as medium and only 10% as large. Thus, although the total tonnage of fish caught in the Lake has grown over the past three decades, the value of the catch in terms of quality, size and revenue has declined.

The number of fishermen increased from about 9000 in 1963 to about 21600 in 1993. In 2000 there were approximately 28000 fishermen working on the Lake, of whom only 10266 were licensed. The number of licensed boats also increased from 2438 in 1963 to 7277 in 1993 and 9665 in 2000. Of these, only 153 are motor boats and the rest are classified as third class boats of three types: the samboak (the smallest), the felouka (medium-sized) and the sailboat (the largest).

Agriculture is probably the second most important economic activity in Burullus Wetland. There are about 19000 Feddan under cultivation within the limits of the Protectorate. Agricultural activity in land close to the Lake shores is rather limited because of poor soil and high soil salinity. However, land reclamation efforts continue to be made on the western side of the inlet (Boughaz) where the soil is predominantly sandy. Agriculture in this area is mostly rain-fed. On the eastern side of the inlet, the area near Baltim is intensively cultivated (irrigated), mainly with date palms and guava. Other crops include tomatoes, grapes, clover, cabbage, cauliflower, watermelons, broad beans, wheat, rice, and maize. In 1956, El-Hamoul Land Reclamation Project was initiated in the southern and southeastern regions of the Lake. However, land in this area is not easy to reclaim. In July 2000, the total area of farmlands in the 5 districts with parts inside the Protected Area was 292419 Feddan, of which about 19000 Feddan fell within the limits of the Protected Area.

Villagers inside the Protected Area breed buffaloes, cows, sheep and goats. The per capita net income of livestock seems to be relatively low. This can be attributed to the limited numbers of heads maintained by each family and the low productivity of the varieties involved. Inhabitants of the Burullus area regularly harvest *Phragmites australis* reeds as fodder for their livestock primarily utilizing the green shoots. Mature reeds are harvested and sold for LE 0.20 – 0.60 per bundle for a variety of uses, including mat making, wind breaks, as building material, fishing nets and bird catching.

Bird catching is a widespread activity in Burullus Wetland, and is largely concentrated in autumn (Quail catching) and winter (water bird catching). Although all forms of hunting are now illegal after the declaration of Burullus as a protected area, it still continues. Quail catching is a traditional activity along the entire Egyptian Mediterranean coast, including Burullus. A variety of nets and traps, are used to catch Quail and other small birds during the autumn season. This activity is carried out largely on the sand bar. In winter catching targets water birds, which are caught using large nets or shotguns. The catch is

usually transported to large towns and cities, such as Rosetta and even Alexandria where the birds fetch higher prices.

A modest tourist industry has existed for a long time in the Burullus area. It is based almost exclusively on Egyptian tourists attracted from the Nile Delta and Cairo during the summer months of June to mid-September. Most of this activity is concentrated in the seaside resort of Baltim. There are only about 164 hotel rooms in the entire Kafr El-Sheikh Governorate. Most of the summer holiday makers in Baltim stay in temporary rentals of chalets and apartments or in privately owned residences, which do not show in official statistics. Despite the diverse natural and cultural heritage of the region, the international tourism potential of the Burullus Wetland, and the Delta as a whole, has not been tapped. This is mostly due to the lack of awareness of the value of these resources and their potential to attract specialized tours.

Burullus Protected Area could have a good prospect as a specialized ecotourism attraction, particularly bird watching. However, the lack of suitable facilities, and the presence of extensive bird catching activities during the primary bird watching seasons (autumn and winter) are all important obstacles for the Protected Area's development as an international bird watching attraction.

14.5. REFERENCES

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Chapter 15
Management Plan

The National Working Group, established under the Project Development Fund (PDF) for the MedWetCoast Project, selected Burullus Wetland to prepare a management plan for many reasons. The first is the high value of the Lake as a breeding area for water birds, both on Egyptian and international scales. In addition, Lake Burullus is a less disturbed wetland in Nile Delta, and is the second largest lake. Moreover, the biodiversity of Lake Burullus is relatively high (more than 700 known species) including 9 endemic species and about 12 threatened species. The fourth reason is the declaring of Burullus Wetland as a Reserve under Law 102/1983 in May 1998, including the whole lake and the sandbar that lies between the northern shores of the lake and Mediterranean coast. After a detailed description, the site has been evaluated along the environmental, social and economic scales (Kassas *et al.* 2002).

15.1. EVALUATION

15.1.1. Ecological Criteria

15.1.1.1. Fragility and threats

Burullus Wetland shares the ecological fragility of aridlands and the threats of unsustainable use of natural resources. Many species, and habitat types in Burullus are threatened by the impact of human activities. Drying parts of the Lake, removal of large quantities of sand from the dunes, uncontrolled reed cutting, bird hunting, the fast growth of fish farms around the southern fringes of the Lake, illegal fishing practices including fry catching near the Boughaz, the excessive inflow of drainage water from the catchment area, water pollution, the construction of the international highway which cut the entire

length of the sand bar, and the fast growing of new human settlements on either sides of the highway are among the serious threats to biodiversity in Burullus.

15.1.1.2. Rarity

A total of nearly 60 rare species are recorded in Burullus: 2 mammals, 24 birds, 2 reptiles and numerous flowering plants and phytoplankton. Rare and threatened habitat types include the sand dunes and salt marshes of the sand bar and the islets (especially Al-Kawm Al-Akhdar and Deshimi), which represent unique habitat types in the entire Mediterranean coast of Egypt. Reedbeds may not be unique for Burullus, but they are of vital importance for resident and migrant birds as well as providing food and shelter for many species of fish.

15.1.1.3. Naturalness

The Burullus Protected Area is endowed with impressive scenery along the seafront, especially on the sand bar west of El-Boughaz and on the sand dunes west of Baltim. The herds of cows and buffaloes left to graze in reed beds and on some of the islets in the Lake (e.g. Al-Kawm Al-Akhdar and Deshimi) have become almost wild. Although the impact of human activities in agriculture, reed grazing and harvesting, fishing, fish farming and urbanization of sizeable areas in some parts of the Protected Area has changed the naturalness of some habitat types, other parts have escaped the change and kept their original environmental status almost intact. Examples of such genuinely natural habitats are two islets (Al-Kawm Al-Akhdar and Deshimi) and the salt marshes on the sand bar which are characterized by relatively high species, community and habitat diversities, including some of the rare and endemic species of flora and fauna.

15.1.1.4. Typicality

The Burullus Protected Area is a mature eutrophic Mediterranean lagoon and a typical wetland ecosystem with a wide range of species and habitat diversities.

15.1.1.5. Special interest

Recorded history of Kafr El-Sheikh Governorate tells of the heroic deeds of the inhabitants of El-Burg and Baltim in defending the country against attempts of foreign invasion through Lake Burullus during the early nineteenth century. Relicts of fortresses on either side of El-Boughaz are witnesses of such deeds. In more recent times, history repeated itself when on the 4th November 1956 the Egyptian Navy was helped by the local inhabitants to repel yet another attempt of foreign invasion. The 4th of November has since been celebrated as the national day of Kafr El-Sheikh Governorate.

15.1.1.6. Size

Burullus is one of the large wetlands along the Egyptian Mediterranean coast, which still retains considerable environmental value. It has numerous islands and some substantial reedbeds. The 65 km of coastal sand bar is still relatively intact, with little urban development and low key agriculture. Because of its size, there is scope to maintain key populations and habitats and, through management, to enhance or restore currently deteriorating ecosystems.

15.1.1.7. Diversity

Site diagnosis studies revealed the richness in species diversity of Burullus Protected Area (Anonymous 2002). This species richness is matched by richness in community and habitat types. It is worth pointing out that the coastal sand dunes west of Baltim town fall outside the official boundaries of the Protected Area. These dunes are rich in vegetation, both in number of species and in community types. They also harbour a number of rare reptile and mammal species. If these coastal sand dunes were to be incorporated into the Protected Area, its species, and habitat diversities would increase.

15.1.1.8. Stability

Reedbeds support a rich ecosystem and, with careful planning, have the potential to be a renewable resource for local people. However, the quality of this key habitat is currently in decline. The danger of this decrease may be fully appreciated in the light of the important ecological role played by these reedbeds. The submerged rhizomes and roots are excellent soil binders, which help prevent erosion and washouts and are reported to be effective in trapping pollutants. A GEF supported project experiments with " artificial wetland" that is reedbed built in the course of one of the principal agriculture drains pouring into Lake Manzala (east of the Delta). The objective is to phytoremediate the water. Reeds also provide shade, shelter and food for many species of fish. The aerial parts are home for numerous species of resident and migratory birds, and the grains are highly nutritive for many species of waterfowl.

15.1.1.9. Ecological position

The ecological role of phytoplankton in Lake Burullus is crucial for a variety of reasons. These organisms are among the major primary producers in the ecosystem through their photosynthetic activities. They are also a major component of the feed readily available for filter-feeding species of fish; fish productivity of the Lake is directly affected by the state of its phytoplankton community. Furthermore, they can be used as important ecological indicators of water pollution as well as in monitoring water quality.

The ecological role played by zooplankton is many-sided. It is food for juvenile and adult fish: the increase in standing crop of zooplankton is concurrent with the increase in annual fish production. It is also useful in

monitoring hydrographic events such as pollution, eutrophication, warming trends and long-term changes in salinity. For instance, the change of dominance from the large species (Copepoda) to smaller species (Rotifera) is a reliable indicator of eutrophication. Application of this principle means that Lake Burullus is eutrophic.

The total number of waterbirds wintering in Lake Burullus and the adjacent marshes may well exceed half a million (Meininger and Atta, 1994). The reed beds are home for the largest populations in the Western Palearctic of the Little Bittern and the Purple Gallinule. The only western Palearctic populations of Painted Snipe and Senegal Coucal are found in Egypt. The world's second largest known concentration of Ferruginous Duck is found in Lake Burullus.

15.1.1.10. Replaceability

The impact of human activities in the Protected Area and its catchment region (as represented by the removal of sand dunes from some parts of the sand bar, reclaiming parts of the water body for cultivation, rain-fed farming in sand formations with crops such as grapes, figs and watermelons, the increase of reed swamps and salt marshes, and the proliferation of fish farms along the southern shores of the Lake) has led to some major changes in the relative areas of various habitat types. Fortunately, sufficient remains of the complete range of Burullus habitats supporting a rich diversity of fauna and flora. However, restoration of areas already lost will be difficult or impossible, and further losses have the potential to severely damage the value of certain habitats.

15.1.2. Socio-economic Criteria

Lake Burullus is the only source of livelihood for part of the population in the Kafr El-Sheikh Governorate. Nearly all human activities in the area depend directly or indirectly on the Lake. Furthermore, the relatively high rate of population growth in some villages and towns (e.g. Baltim) adds to the reliance of the local inhabitants on the resources of the Lake and the adjacent farmlands and fish farms.

15.1.2.1. Agriculture and fish farms

The productivity of reclaimed lands is low and variable because of high soil salinity and unreliable water supply, hence the growing tendency to transform reclaimed lands from agriculture to the more profitable activity of fish farming. Land reclamation conflicts with nature conservation objectives by reducing the size of the lake. Stocking of fish fry taken illegally from the lake or El-Boughaz is another potential source of conflict, both with nature conservation and lake fishery interests. Fish farms also discharge nutrient enriched water which enters the lake.

15.1.2.2. Fishing

Fishing is the most important economic activity within the Protected Area. The total fish production of Lake Burullus increased gradually from 7549 ton in 1963 to 55283 ton in 1999. Mullets, fish of saline habitats, are the most economically valuable species. The percentage of mullets in the annual production decreased gradually from 44.7% in 1963 to only 17% in 2000. This was accompanied by a gradual increase in the production of the cheaper tilapia from 42% in 1963 to 62% in 2000. This reflects a change from availability of predominantly saline to freshwater fish. This is clearly manifest in increasing in production of the freshwater species *Clarias gariepinus* and *Bagras bajad* from 188 and 220 ton in 1963 to 2459 and 706 ton in 2000, respectively. Higher fishing effort and higher production of poorer quality fish is necessary to maintain incomes after the loss of the economically more valuable marine fish species.

15.1.2.3. Reed economics

Field studies of reed economics carried out on a sample of 100 families with an average size of 7 person family^{-1} and a working season of 120 day year^{-1} led to the following statistics: gross return = LE 101190 , net return family^{-1} season^{-1} = LE 832, expenditure = LE 18000, net return person^{-1} season^{-1} = LE 118.8, net return = LE 83190 and net return person^{-1} day^{-1} = LE 0.99 (Shaker *et al.* 2002). By Egyptian standards, the net return of just under LE 1.0 per person per day is quite low. Furthermore, the effect of the method of reed cutting (above or below the water surface) on the rate of regeneration of reeds, and consequently on the sustainable reed exploitation, is yet to be investigated. Reed cutting has both positive and negative values for nature conservation. Over-exploitation, or the disturbance or destruction of sites of known environmental importance, have negative effects. However, nature conservation benefits from reed cutting can be considerable. It limits the rate of expansion by reeds into new, open areas of lake; and within a planned programme of rotation can produce a mosaic of beds of different age and structure, which enhances the diversity of the ecosystem.

15.1.2.4. Bird-hunting

Bird catching is not an economically significant or stable activity in Burullus area, although some individuals and families might resort to it on a seasonal basis only in order to augment their income. Conflicts with nature conservation arise particularly when threatened species, such as the Corncrake, are taken. Bird catching, particularly within a protected area, is counter-productive in attracting eco-tourism to the area, which has the potential to bring in far more money than bird catching does.

15.1.2.5. Tourism

The international tourism potential of Burullus area remains largely untapped. This is mostly due to: 1- the lack of awareness, on the part of both the local inhabitants and municipal authorities, of the economic value of this industry and its potential contribution to the advancement of their well-being; 2- all Islamic sites of historical and touristic value remain to be uncovered from beneath massive sand dunes; and 3- security considerations related to combating illegal smuggling along the coast line.

15.1.3. Potential Value

15.1.3.1. Ecological improvement

Lake Burullus plays an extremely important ecological role. It acts as a buffer zone between the Mediterranean Sea and Nile Delta. It stops seawater intrusion into the productive agricultural lands in Nile Delta. It is also a basin for the purification of the drainage water pouring from the catchment area in Nile Delta before its discharge into the Mediterranean. Conservation and improvement of the ecological conditions on the sand bar between the Lake and the Sea would have decidedly beneficial consequences for Egypt as a whole.

15.1.3.2. Landscape and visual improvements

The wide open vistas, and generally unspoiled character of the lake and its natural habitats, retain their attractiveness. This can be improved further by: 1- campaigns to pick up rubbish and other discarded material; 2- "keep Burullus tidy" campaigns, aimed at villages and children; 3- strictly enforced planning laws to prevent urbanization of the coastal strip now crossed by the international road; and 4- in other areas still retain their wild or natural character.

15.1.3.3. Education and research

Burullus Reserve Area can play a significant educational role through the organization of excursions for school and university students to attend practical classes and carry out field studies. Improvement of research facilities in the Reserve (e.g. laboratories for water and soil analyses, herbarium, metereology station, equipment for identification of flora and fauna, and data bases) would greatly enhance co-operation between Burullus and other research institutions in the country with beneficial results for both.

15.1.3.4. Recreation and leisure

Burullus Reserve Area is a preferable destination for some holiday-makers who come from adjacent villages and towns to spend the day on the Lake and some of the islets. However, with some improvement in local hotels, clubs, cafés, restaurants and other catering facilities in Kafr El-Sheikh Governorate, the Reserve could become one of the major tourist attractions in the country, especially for people from neiboughring Governorates (Gharbia, Dakahlia, Sharkia, Behaira and Menoufia) in and around Nile Delta who have to

travel long distances to spend their summer vacations in other sea-side resorts. The Baltim summer resort is outside the Reserve.

15.1.3.5. Generation of revenue

The resources of Burullus are already being used to their limit, and beyond, by the local people. Sustainable resource management is essential if these resources are not to be steadily reduced and squandered. To counter short-term loss of income in applying sustainable management, other sources of revenue must be identified. Fortunately, Burullus has huge potential value in its wildlife. Wildlife resources are increasingly being recognized as a means of bringing new money into local economies. There is now a very big market in eco-tourism throughout the world. Wildlife enthusiasts from Europe and North America, in particular, are drawn increasingly to sites of high wildlife value and natural beauty. Protection followed by promotion of Burullus's environmental riches can combine to bring international tourists, to the site. This can only be achieved through careful planning, including the development or support of more diverse activities (such as handicrafts, training of local people as guides and wildlife specialists), improvement of facilities and infrastructure and the willingness of local communities and authorities to participate in the development.

15.1.3.6. Demonstration possibilities to other protectorate managers

The experience gained by the Burullus management team in preparing and implementing a conservation management plan places them in an ideal position to act in future as hosts and demonstrators to other protected area managers, both from Egypt and elsewhere in the Mediterranean. Not only is the site suitable, but a modern purpose-built facility is available: the new Visitor Center.

15.1.3.7. Stronger protection through legislation or designation

The implementation of management will strengthen enforcement of current legislation and provide the first step towards protection and enhancement of the nationally and internationally important biota of the site. A management plan agreed by all participants and stakeholders will strengthen resolve and create a co-operative approach to safeguarding the future not only on the site's environmental values, but also the resources on which the local population depends.

15.1.3.8. Public visitor enjoyment

The opening up of a new visitor center, improvement of facilities and information, development of participatory programmes and all the other initiatives proposed in this management plan will form the basis for greater public involvement in and enjoyment of the Reserve and its assets.

15.1.3.9. Maintenance of heritage and way of life

Emphasizing the need to protect resources by using them in a sustainable manner, the management plan will conserve not just wildlife but the traditions and way of life which have maintained the local human population for generations and which are such a feature of Burullus Wetland. The social and historical character of the site is also an asset in attracting eco-tourists, many of whom appreciate cultural heritage as much as wildlife.

15.2. IDEAL LONG-TERM OBJECTIVES

The management plan of Burullus Reserve has the following five long-term objectives (after Kassas et al. 2002): 1- to restore ecological (including biodiversity) and landscape values which have been lost or damaged, 2- to maintain and enhance the ecological and landscape values of the site, 3- to conserve Burullus resources through sustainable management, 4- to improve socio-economic opportunities for local people and 5- to develop public awareness for nature conservation.

15.2.1. Restoring Ecological and Landscape Values

Studies in a range of disciplines have demonstrated that the condition of the site has deteriorated alarmingly in recent years. The major over-riding factor in this is the use of the lake as a discharge area for agricultural drainage water. This has had a severe effect on water balance, water quality, water condition, natural communities and income generation for people reliant on the lake. Restoration of these lost or deterioriated values will require a radical re-evaluation of the hydrology with a view to returning it to a more natural system.

15.2.2. Maintaining and Enhancing the Ecological Values

This objective relies heavily on the first one. Unless a return is made to a system which replicates the previous natural hydrological system, maintenance of current values can not be achieved and management measures would, at best, slow down the rate of deterioration already occurring.

15.2.3. Conserving Resources Through Sustainable Management

There is no point in enacting restoration measures only for the gains to be eroded by unplanned, unsustainable exploitation of resources. In order to fully restore and conserve ecological and landscape values, the resources which make up these values need to be maintained. This can only be achieved by application of the principle of sustainable resource management.

15.2.4. Improving Socio-economic Opportunities for Local People

Local stakeholders will understand the principle of sustainable use of resources as a means of maintaining the necessary levels of resources for future years. However, in most cases they are not in a strong enough financial position to reduce or set aside activities which determine their income in favour of a

long-term approach. In reality, they cannot be expected to forego part of their income as a sustainability measure without compensating for that loss elsewhere. Currently, resources are over exploited and, with a growing human population, pressure on those resources can only increase. Introduction of the concept of sustainable resource management must therefore be accompanied by alternative income generation opportunities and particularly those which diversify the money-earning process.

15.2.5. Developing Public Awareness for Nature Conservation

Public awareness campaigns make local people more aware of the natural and cultural values of their site and how these are their support system by supplying the resources on which they rely. Greater awareness and respect for nature conservation makes the task of implementing conservation and resource management measures much more effective. Awareness programmes can extend to people from outside the local environment, including people from abroad, attracted by the information such programmes engender. Most importantly of all, it extends the skills, knowledge and interest of local people. The environmental and cultural values of Burullus are a resource, which is currently largely unexploited. Greater interest and knowledge can translate into using that resource, for instance in educational, interpretation and eco-tourism purposes. Opportunities thus emerge, for instance related to eco-tourism, which diversify income generation without putting further strain on the resources.

15.3. OPERATIONAL OBJECTIVES

The principal objectives define the direction that the management programme will take, but not the detail. To achieve each objective, a number of measures and tasks are required. Each of these needs its own "operational objective" to ensure that it complies with the general directives of the plan, that the outcome or result can be assessed and that it relates directly to one or more of the principal objectives. Once the operational objectives have been determined, a series of measures or "projects" can be developed in order to achieve them. Thus there is a step-wise progression in devising a management programme from principal to operational objective and on to identification of projects or measures. Taking into account the values of the site, its needs and constraints, the following operational objectives have been identified. Some are related to more than one principal objective, but they are arranged in relation to the principal objective to which they most closely correspond.

A- Restore ecological and landscape values which have been lost or damaged

1. Restore salinity level
2. Initiate a network for monitoring water quantity and quality
3. Treat water for re-use

4. Monitor climate changes

B- Maintain and enhance the ecological and landscape values of the site
1. Propose a scheme of zonation
2. Take *in situ* measures of species conservation
3. Initiate *ex situ* conservation measures
4. Establish a system of data management
5. Monitor species diversity
6. Initiate a programme of research

C- Conserve Burullus resources through sustainable management
1. Improve the situation of law enforcement
2. Revise legislative and institutional aspects
3. Sustainable use of fish resources
4. Sustainable use of reed growth

D- Improve socio-economic opportunities for local people
1. Initiate capacity-building schemes
2. Develop eco-tourism
3. Fund raising

E- Develop public awareness and respect for nature conservation
1. Raise level of public awareness
2. Initiate publicity programmes

15.4. IMPLEMENTATION

15.4.1. Management Strategies

After the determination of the operational objectives, the next step is to decide how the objectives will be met. Different methods are required for different measures, and indeed some measures may require different strategies depending on location. The approach to a particular operational objective also depends on the category to which it belongs. For instance, the approach required to practical issues, such as maintenance of facilities, requires skills and considerations different from those of maintaining habitats or biodiversity.

15.4.1.1. The main areas of activity

The main areas of activity can be summarized as follows: 1- restoring, maintaining or enhancing the habitats, biotopes, habitat structure and diversity of habitats and species; 2- public use, recreation, visitor facilities, education, demonstration and study or research; 3- estate management; and 4- miscellaneous other elements.

Habitats and species: The choices to be made here include non-intervention, limited intervention and active or strict intervention. Burullus is such a large site that active intervention is not a realistic possibility, particularly

with the limitations of staff and resources. Instead, the strategy of active intervention will be implemented solely in areas of highest habitat and biodiversity value. This will be achieved by designation of zones in which strict protocols for the conservation of the zone and its interests will be applied. Other intermediate ("buffer") zones will also be designated, supported by sets of regulations which will achieve limited intervention (though mainly on a non-enforcement basis). In reality the status of areas outside the strict conservation zones, will be mainly non-intervention until publicity and public awareness measures can raise them to limited intervention.

Public use: Much of the site will be open access. Some activities will be liable to permit or permission and some high conservation areas will be closed to the public. Visits for research, study, education and appropriate recreational activities will be encouraged, though access to sensitive conservation zones will be largely restricted to bona fide research workers. Because visits are to be encouraged, a strategy of active publicity will be pursued, which will be linked with public awareness, education and other campaigns. A visitor center is being constructed and further facilities are planned for visitors.

Estate management: A considerable number of management measures cannot be carried out without planning for practical issues such as boundaries, fences, vegetation management and so on. These need to be costed in any management plan and are best presented as one or more "projects".

Miscellaneous: Issues such as legal instruments and regulations, employment of staff, contracting of services, accommodation, equipment, and health and safety statements are all part of management planning and are best presented as one or more "projects" in their own right.

15.4.2. Zoning and prescriptions

The zoning of certain areas helps to identify and protect key sites for conservation, to establish rules and regulations for the enforcement of strict or limited intervention and to clarify and simplify management implementation by staff and other participants.

15.4.2.1. Units

The whole of Burullus Protectorate Area has been allocated to one of three management categories: core zone, buffer zone or transitional zone (Shaltout 2002). The core zones are areas of strictest intervention and correspond to ecological units. The other zones, of lower intervention management priority, are best treated as functional units – although they often include one or more clearly defined ecological units.

15.4.2.2 Management zones

15.4.2.2.1. Core zones

The core zones at Burullus Protected Area are locations of highest environmental and/or cultural value and therefore requiring a higher level of management intervention. Selection of the core zones was based on their suitability in terms of size, ease of protection and as representative areas of highest floristic and faunistic community diversity in the Protectorate. The aims of designating these areas as core zones are: 1- to protect endemic, rare and globally-threatened species; 2- to minimize the impact of human activities on well-established, rare or unique habitat types; and 3- to allow visitors to experience, enjoy and benefit from the different physical, biological and cultural aspects of the Protectorate. In this respect, three core zones are proposed (Fig. 15.1). Core zone 1- includes the two islets of Al-Kawm Al-Akhdar and Deshimi. Al-Kawm Al-Akhdar is the largest islet in the Protectorate (approx. 3 km^2), it contains: 63 of the 89 species of plants recorded in all islets including the endemic *Sinapis arvensis* subsp. *allionii*, large numbers of animal species, 4 of the 6 habitat types identified in all islets, 7 of the 13 plant communities in the Protectorate. Deshimi islet (approx. 1 km^2) has the second highest species, community and habitat richness in the Protectorate, and its surface is characterized by high sand dunes. Both islets are important stopover sites for many resident and migratory birds, and most of their area is largely uninhabited.

Core zone 2 includes the section of the sand bar east of El-Hanafi village with a width of 2.5 km, and extends between the sea shore in the north and the northern shore of the Lake in the south (approx. 5 km^2). This site includes also all types of sand formations (sand flats, sand hillocks, and sand dunes) prevailing in Burullus, as well as wet and dry habitats of the Lake and shores. It has high species diversity, coupled with high phytomass; and unlike the rest of the sand bar, it is free of rainfed agriculture, settlements and other human impacts.

Core zone 3 includes the sea inlet (El-Boughaz), which is the only passage of exchange of water, and biota between the Lake and the sea (approx. 20 km^2). It is the richest part of the Lake in the fry of different mullet and other marine fish species This inlet is one of the most fragile natural habitats in the Protectorate, the erosion-accretion activities lead to widen it at times and to close it at others.

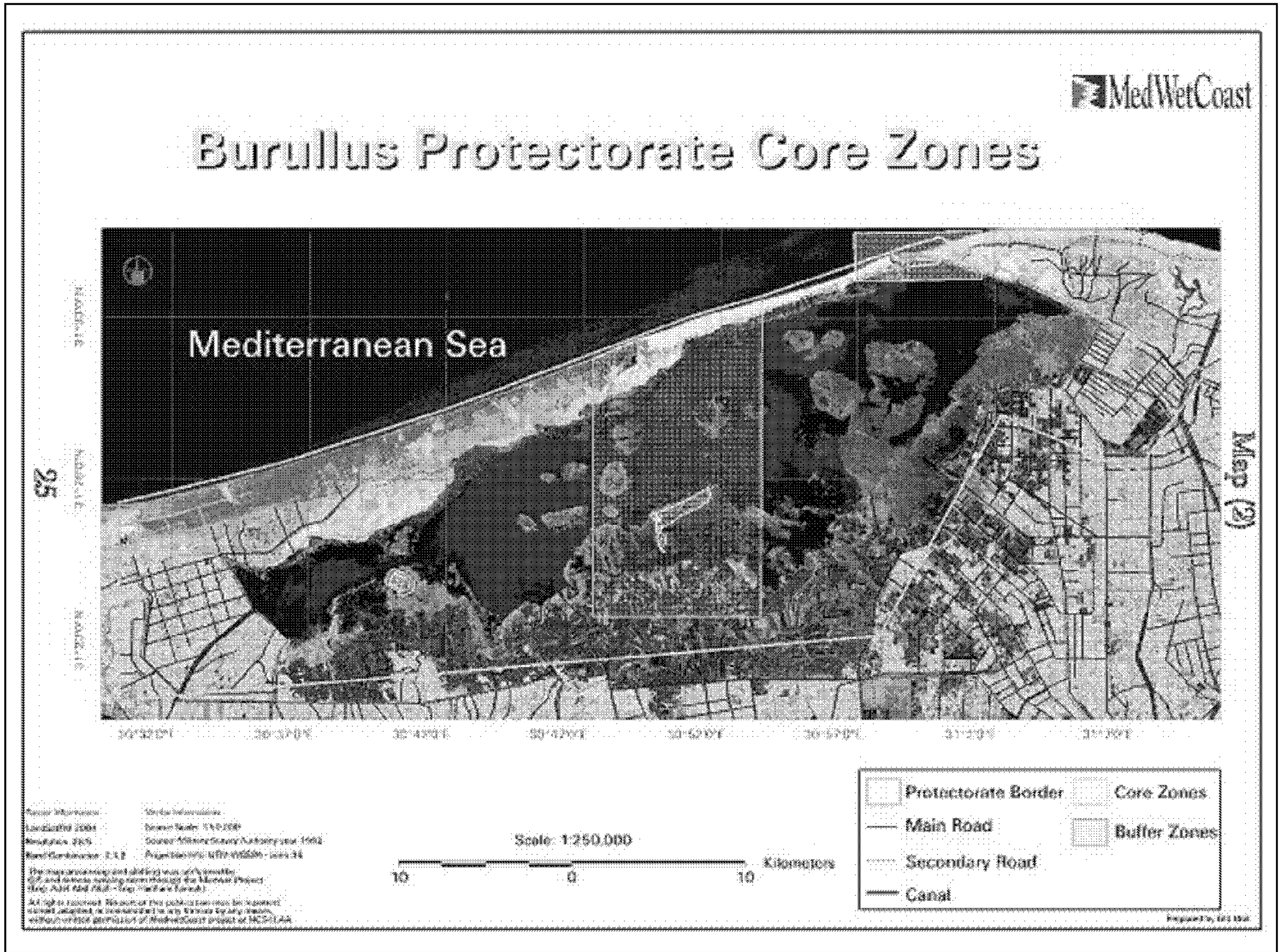

Fig. 15.1. **Map of Lake Burullus showing the core zones**.

15.4.2.2.2. Buffer zone

The definition of a buffer zone is a zone outside but immediately surrounding a core zone. Its purpose is to act as buffer for the core zone, meaning that restrictions can be placed on certain activities within the buffer zone which are liable to impinge on or damage the interests of the core zone. Only one buffer zone is suggested to surround Al-Kawm Al-Akhdar islet (from core zone 1) and the whole of core zone 2. It extends between latitudes 31° 23' 47" and 31° 31 53" – 31° 33' 41" N, and longitudes 30° 37' 21" and 30° 53' 40" E. It covers an area of approximately 170 km^2.

15.4.2.2.3. Transitional zone

The definition of a transitional zone is one that falls within the Protected Area and its rules and regulations but is not otherwise subject to specific intervention management. This does not mean that areas designated as transitional zones have no conservation significance. The objective of conserving resources through sustainable management applies as strongly to this zone as any part of the Protected Area. Owing to the immense biological, ecological, economic and cultural importance of Lake Burullus, it is suggested that the entire area (410 km^2) should be regarded as the transition zone of Burullus Protected Area. All the sand bar that separates the Lake from the sea should be treated also as a transitional zone , as well as the terrestrial area south of the Lake and close to the shore.

15.4.2.3.Touristic zoning

A map of accessible and inaccessible islets in the Lake and tracks on these islets and on other terrestrial parts of the Protectorate should be drawn and made available to visitors. Clear road-signs with names of places and arrows indicating directions to them should be fixed along all tracks and cross-roads. Daily patrols by rangers and community guards must pay due attention to the presence of these signs, their clarity and ease to follow by visitors.

15.4.2.4. The impact of zoning

The proposed scheme should help in conserving the endemic, rare and globally threatened species as well as to conserve unique habitat types without imposing undue restrictions on the use of the resources by local inhabitants or the enjoyment of cultural features and the impressive scenery by the visitors.

15.5. ACTION PLAN

15.5.1. Management Action Plan

There is need for five major programmes that respond to the following five principal objectives: 1- restore ecological and landscape values which have been lost or damaged, 2- maintain and enhance the ecological and landscape

values of the site, 3- conserve Burullus resources through sustainable management, 4- improve socio-economic opportunities for local people, and 5- develop public awareness and respect for nature conservation. Projects have been devised each of these headings. These respond to the operational objectives enumerated in 15.4 above. Additional projects, coming under the general heading. Estate management and administration are also included in the plan, these are not directly related to any one principal objective, but are essential prerequisites if the principal objectives are to be achieved. These additional considerations can be converted to an objective: to provide the administration and facilities necessary to implement management measures supporting the principal objectives.

The advisory committee should be slightly re-structured to management (steering) committee and consists of: Governor of Kafr El Sheikh (Chairman), Secretary-General of Kafr El Sheikh (Vice-Chairman), MedWetCoast Project Manager, Director of Lake Burullus (representing the Ministry of Agriculture), and Manager of the Protectorate (Secretary). The local representative of each of the following institutions are also included: Ministry of Health, Ministry of Housing and New Communities, Coast Guards (representing the Ministry of Defense), Police Force (representing the Ministry of Interior), and Chief of Fishermen Co-operatives. This preliminary structure may be reviewed every two years and the new structure is appointed by a decree issued by the Governor of Kafr El Sheikh. The role of this Committee should be re-formulated from being merely consultative to the more effective function of decision-making. Bi-monthly meetings of this committee should deal principally with the following tasks: setting policies for the management of the site within the framework of the management plan, supervising the implementation of projects indicated in the management plan, reviewing periodically the progress made by the management team in the implementation of projects, and proposing changes in the work plan as the need arises.

A further executive committee headed by the Manager of the Protectorate will assist the above committee and, in particular, undertake the following functions: implement the directives of the Management Committee, carry out the day-to-day tasks of patrolling, and report to the Management Committee on all new developments in and around the site.

Implementation of these programmes and their component projects is an integral part of the management of the Protectorate. Some of these projects are priority activities that are basic requirements for the operation of the Protected Area. Others are complementary actions that ensure the sustainability of the endeavour. Some of these may be implemented in a second phase of operation. First priority projects are mainly the direct responsibility of the Protected Area

management team. Others may require co-operation and shared responsibility between management and competent governmental and non-governmental stakeholders. The management committee will assign these shared functions.

15.5.2. Programmes and Projects

Programme 1. Restore Ecological and Landscape Values which Have Been Lost or Damaged

Project 1.1. Restore the Lake's natural hydrological system

This part of the action plan aims at restoring the diversity of water quality (salinity) in Lake. Under previous pristine conditions the Lake represented on ecotonal pattern between saline (marine) water in the northern reaches (fed through the inlet) and brackish water in the Southern reaches (fed by agricultural drainage and surplus freshwater). This provided habitat for diverse fish species. At present the Lake is dominated by brackish (almost fresh) water. This programme will require continuous monitoring of water quantity and quality (Project 2.2), management of the hydrology of the Lake through control over the volumes of inflowing drainage water. The research programmes (Project 2.4) will include hydro-meteorological studies (including rates of evaporation, among others).

Hydrological control measures may include: 1- re-institute procedure of "winter closure" in the southern outskirts (Kafr El-Sheikh Governorate) of Lake Burullus; 2- divert part of the drainage water to be reused in newly reclaimed lands, or to flow to the sea (scheme named El-Moheet drain is an effective mean); and 3- maintain the sea inlet (El-Boughaz) open and clear to ease seawater flow into the Lake. Hydrological control measures will require engineering schemes of scale and cost. Cost estimate of this programme is $ 2000000.

Programme 2. Maintain and Enhance the Ecological and Landscape Values of the Site

This programme represents the core element in the plan of action; the measure of its success is the ultimate indicator of achievements. Projects included in this programme require the participation of all stakeholders and the support of the other four principal programmes.

Project 2.1. Implementation of zonation scheme

This project will aim at the demarcation of the zones of the Protected Area .This may include 1- closure of core zone, designed fencing that does not bar natural ecological exchange but bar human interference of the terrestrial sites, and designed warning signs around the two core-zone islets; 2- signs that mark the boundaries of the buffer zones, paved tracks in terrestrial buffer zones

designed to lead to sites of interest to visitors; and 3- clear signs and notices will be informative and indicate what is permissible and what is not, these notices will also list briefly and clearly elements of good behaviour in the Protected Area. The ecological zonation may require modifications in subsequent years in the light of added information resulting from monitoring and research activities. Modification may entail changes in demarcations, signs and tracks. Cost estimate of this project is $ 100000.

Project 2.2. Establishment of monitoring networks

This project will aim at establishing an operative environmental, including biodiversity, monitoring network. The function of this network is to feed the data banks with up-to-date reports on the status of the ecological elements of the Protected Area. This project may include:

1- establish a set of points for periodical sampling of water for analyses, the set will represent the various ecological zones of the Protected Area, analyses will include water chemistry, physical features and biological (plankton and submerged biota) elements, sampling will also include bottom sediments;

2- establish a programme for monitoring diversity and status of species, the purpose is to monitor species and their populations and to use this information to indicate the ecological health of the habitats;

3- data fed to the data bank will enable the production (once every 3 – 5 years) of revised lists of the principal biota elements, including flora, avifauna, mammals, herpetofauna, insects and arachnids and plankton;

4- selected samples (vouchers) will be deposited in *ex-situ* reference collections.

This is project and continuous activity venture, would require a team of trained personnel. Cost will include: 1- establishment of monitoring networks ($ 500000), 2- training (included in project 6.1), and 3- running yearly expenses (regular budget).

Project 2.3. Establish reference collections and data bank

This will be accommodated in the Visitors' Centre and be elements of a natural history museum (for education and research). The data bank will also provide the Protected Area Management Committee with information necessary for assessing the operation of the management plan and means of its development. This central body will be linked with the monitoring network (Project 2.2) and with ongoing research activities (Project 2.4). Reference collections will include: flora (herbarium), avifauna, mammals, herpetofauna, insects and arachnids, fish, and mollusks. A documented reference collection of soil types will be built, kept and updated with additional types to be discovered in the scientific surveys. A data bank is a computerized depot for data on biodiversity (with its various elements), ecological monitoring and research results. It will also contain a geographical information system (GIS) for Lake Burullus. This will eventually be a part of the national network of data-bases of

protected areas and biodiversity. The data bank will issue periodical reports on the status of conservation and sustainable use of natural resources. Cost estimate is $ 500000.

Project 2.4. Programme of research and studies

There will be need of research work on population and ecosystem dynamics, assessment of ecological changes, ecological responses of key species, etc. There will also be need for research studies related to sustainable use of species especially fish species. Environmental impact studies related to new development schemes (e.g. the new fishing port, the new international highway, land reclamation projects, summer resorts schemes, etc.) need to be carried out and submitted to relevant authorities. Because fisheries and fish-farming are important socio-economic activities in Lake Burullus, there is need for a series of research studies with the purpose of finding bases for sustainable use of fish resources. In particular there is need for establishing scientifically based quotas of commercial species of fish. The whole area of northern Delta including Lake Burullus is a vulnerable site to climate change related sea-level rise. Research programmes need to address this issue. These research programmes may be carried out by the technical staff of the Protected Area or staff of Universities and research institutions. All research needs to be coordinated within a planned programme of the Protected Area. Funds need to be available for supporting these research activities. The cost estimate of this project is $ 200000 per year.

Project 2.5. Wildlife clinic

The operation of the Protected Area would need to avail itself of facilities for: a wildlife clinic, particularly important for marine animals and migratory birds reaching the shores of the Burullus sand bar in need of medical care. Cost estimate is $ 20,000.

<u>Programme 3. Conserve Burullus Resources Through Sustainable Management</u>

Project 3.1. Sustainable use of reedbeds

This programme will sustain surveillance of reed growth through a network of sites for monitoring standing crop. Research studies (Project 2.4) on the ecology and biology of the reed-swamp ecosystem will provide guidance for harvesting. In the light of information collected from monitoring and research an annual schedule for use will be set by the Management Committee. Cost estimate, additional to contributions of other programmes is $ 10,000.

Project 3.2. Develop legal and institutional structures

The purposes of project include: development of legislative instruments operative in the Protected Area and its associated territories, improve prospects

of law enforcement relevant to environmental management and conservation of natural resources, define roles of institutions participating in management of the Protected Area and its associated territories. This project may include:
1- organize series of lectures and panel discussions on legislative instruments operative in the Protected Area, audience may include members of the management committee, councils of Kafr-El-Sheikh Governorate and the five concerned districts, and senior members of the departments of local government;
2- revise and resolve conflicting elements of the legislation, close loop-holes through which violations may escape punishment, and provide the managers of the Protected Area and their partner stakeholders with support of law;
3- develop guidelines for defining roles and responsibilities of institutions participating in management of the Protected Area, and for integrating the roles of institutions that issue licenses for fishing, hunting, and boats;
4- develop facilities available for law-enforcement bodies: the manager of the Protected Area, Water Surface Police Force, police stations to be increased from the present number of 2 to 3 - 4, and increase the number of boats available for monitoring and policing.
5- set and enforce quotas, including timing of fishing, the purpose is to minimize stock depletion and to sustain ecological equilibrium, this should be based on sound scientific inventories.

This project requires legal and administrative studies that are discussed and debated in appropriate for Law experts, civil society bodies including fishermen associations, and government technicians, should take part in these fora. Cost estimate for studies is $100000, and for facilities for law enforcement is $1000000.

<u>**Programme 4. Improve Socio-economic Opportunities for Local People**</u>

Project 4.1, Develop alternative livelihoods

The purpose of this project is to develop alternative sources of income or further develop existing sources so as to alleviate excessive ecological pressures of prevalent livelihood system (fishing). This project gives priority to participation of women, and may include: 1- cottage industries, this includes development and further improvement of existing industries and rehabilitation of industries that were once prevalent, necessary technical and marketing studies needed, programmes for promoting products, a small revolving fund needs to be available; 2- eco-tourism, organized guided tours for holiday-makers, this could provide during summer (July – September) alternative use of fishing boats for Lake-voyages in unrestricted parts of the Protected Area; and 3- establish public amenities to visitors, including eco-lodges, special-meals restaurants (e.g. sea-food and indigenous meals).

This project requires active participation and support of local societal bodies (e.g. NGOs and fishermen associations). The first preparatory year will be spent in studies, planning and establishing the support facilities including a revolving fund. Subsequent years will be for initiation and development of the project. Cost estimates of the first year is $ 100000, subsequent years need $ 200000 per year, and revolving fund of $ 500,000.

Programme 5. Develop Public Awareness and Respect for Nature Conservation

Project 5.1. Public awareness and participation

The purpose of this project is to raise the awareness of people of all ages and gender so as to ensure their support to, and participation in, the operations of the Protected Area. This project is a shared priority and may include: 1- guided visits of school and university students to parts of the Protected Area and its Visitors' Centre, these visits will be available to all students of Kafr-El-Sheikh Governorate, with repeated visits to students in the five districts that share the Protectorate; 2- public lectures in the district cultural centers, special seminars for members of the village and municipal councils and executives; 3- special workshops for the NGOs interested in fields of environment and conservation, to be informed about activities in the Protectorate and to solicit their support and participation; and 4- a publicity programme that includes publish an information newsletter, articles in local and national press, presentations in the Delta TV, and produce video-films to be made available to schools and NGOs, among others.

This project requires participation of the Protected Area management and associated institutions. Cost estimate per year is $100,000.

Project 5.2. Build bird watching hides

The purpose of this project is to build 5 small wooden hides in selected sites in the unrestricted zone of the Protected Area. These hides will be available to visitors with interest in bird watching. Cost estimate is $ 10000.

Project 5.3. Children's playground

The operation of the Protected Area would need to avail itself of facilities for a playground for children in the area of the Visitors' Centre, this will combine education and recreation functions. Cost estimate is $ 5000.

Programme 6. Provide the Administration and Facilities Necessary to Implement Management Measures

Project 6.1. Manpower development.

The purpose of this project is to provide the Protected Area with the manpower necessary for its operations. Three categories of personnel need to be

recruited and trained: rangers, technicians for monitoring programmes, and community guards. This project will primarily include initial training courses in Burullus and in other protected areas in Egypt, especially in Sharm El-Sheikh Training Centre; and may also include training abroad. Initial training will be completed and refreshed in the years. This project is in a first priority category, initial training in the first 2- 3 years, refresher training is continuous. Cost estimate is $ 500000.

Project 6.2. Fund raising

The purpose of this project is to secure flow of financial resources needed for the effective implementation of programmes comprising this plan of action. Governmental and non-governmental resources including donations, and international donor sources need to be explored and tapped. Sources from the Protected Area (e.g. entrance fees, and licensing fees) could also be a significant element. Exploratory studies need to be carried out by professional experts, subsequent negotiations with national and international sources (bilateral and multilateral) need to be initiated, and if legal actions (related to levies or charges) are necessary steps would be undertaken. Appointment of a fund-raising officer may be necessary. Cost estimate of preparatory studies to be carried out by expert consultants, and of funding promotion activities is $ 10000.

Additional Actions

The human settlements in villages and towns associated with Lake Burullus, and the prospected settlements that are likely to develop in association with the international highway are sources of considerable volumes of solid waste and sewage. Part of these materials will be discharged, mostly untreated, to the Lake and be a source of pollution to be added to the discharges of the agriculture drains. The management plan and action programmes need to address this issue in close colaboration with local authorities who have plans to address the problems of waste. The Protectorate management, with the support of the Management Committee, will use its resources to assist providing priority to the settlements in direct contact with the Lake.

15.6. SUMMARY

Surveys showed rich biodiversity of planktons, higher plants, and fauna including birds. The Lake is a wintering area of international importance for waterbirds. Biodiversity includes numbers of rare, endemic and threatened species. Fisheries provide the principal life-support system for the inhabitants: production approximates 51000 ton year^{-1}. Other resource uses include: agriculture, livestock farming, fish farming (about 155000 ton year^{-1}), reed harvesting, bird hunting, tourism and recreation.

The Lake and its surroundings are subject to ecological constraints that relate to excessive use of resources such as land reclamation, fish farming, over-fishing, over-hunting, and overwhelming flow for drainage water. Likely future constraints relate to impacts of new development projects, including: the international highway that runs along the sand bar, fishing port to the west of El-Boughaz, future sea-side resorts, etc. To this may be added the likely impacts of future climate change including sea-level rise.

The main long-term objectives of the present management plan include: 1- to restore pristine ecological and landscape values, 2- to maintain and enhance ecological and landscape values, 3- to conserve the Burullus resources through sustainable management, 4- to improve socio-economic opportunities for local people, and 5- to develop public awareness for nature conservation. The management plan aims at achieving the five main long-term objectives by 2010 through field actions (programmes and projects), and establishment of effective institutional arrangements. Six principal programmes could be implemented during the initial two years: five correspond to the 5 long-term objectives, and the sixth is to provide the administration and facilities to implement the plan. 13 projects under these six programmes are outlined, with total cost estimates of $ 5650000.

15.7. REFERENCES

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COLLECTIVE SUMMARY

1- General Characteristics

Burullus Wetland (i.e. Burullus Protectorate Area) is located along the Mediterranean coast in the northern part of Nile Delta. It is bordered from the north by Mediterranean Sea and from south by the agricultural lands of northern Nile Delta. Burullus Wetland belongs administratively to Kafr El-Sheikh Governorate. It lies in a central position between the two branches of Nile: Damietta Branch to the east and Rosetta Branch to the west. The Protectorate includes the entire area of Lake Burullus with numerous islets insides it, as well as the sand bar that separates the lake from the Mediterranean Sea, with a shoreline of about 65 km. The total area of this Protectorate is 460 km^2.

The shoreline of Lake Burullus takes several forms related basically to its formation, origin and evolution. It has an oblong shape extends for a distance of 47 km along NE-SW axis. The width of the lake from north to south varies from site to the other. The western sector has the least width which does not exceed 5 km, then its increases in the middle sector to reach an average of 11 km. Lake Burullus had lost about 49% of its size along 112 years (from 1092 km^2 in 1801 to 556 km^2 in 1913), and about 62.5% by 1997 (410 km^2).

Lake Burullus is a shallow lake with a depth varies between 40 cm near the shores and 200 cm near the sea outlet (Boughaz El-Burullus). The field studies using remote sensing indicated that the deepest parts lay in the middle sector of the lake where the depth reaches 200 cm, and also the southern parts of the western sector (west of Doshimi islet). The eastern sector is the shallowest, where the depth does not exceed 20 cm near the shore, but increases westwards until it reaches about 70 cm.

The main basin of Lake Burullus is classified into three sectors: eastern, middle and western, each one of them has some sort of homogeneity in the geomorphological, hydrological and biological characteristics. The islets scattered in the lake form physical isolations between these sectors.

The marine bar (i.e. sand bar) of Lake Burullus is the zone that separates the Mediterranean coast in the north from the lake shore in the south. It covers an area of about 165 km^2. Although the surface of this bar is relatively flat, but it has different geomorphological features that had been formed upon it as a result of the evolution and development of the geomorphological processes (sand flats, sand dunes, sand hillocks, salt marshes, tidal flats and sea outlet). Some of these features were related to the sedimentation process such as sand

flats, sand dunes and sand hillocks; and some others were due to change of sea level like salt marshes and tidal flats.

Many islets with different sizes are distributed in Lake Burullus. Due to the continuing the effects of the geomorphological processes (e.g. sedimentation, erosion and water flooding), the number, size, dimensions and locations of these islets change from time to time. They move from their locations or merge together when become close to each other. The recent number is 30 islets that take different shapes such as longitudinal (e.g. Dibar), circular or oval (e.g. El-Zanka), triangular (e.g. Doshimi), arc shape (e.g. Shishet Al-Agoza), curved (e.g. El-Zoaya) and irregular (e.g. Absak).

The northern part of Nile Delta belongs to the Mediterranean arid region. The climatic conditions are warm summer (20 to 30 °C) and mild winter (10 to 20 °C). The aridity index (P/PET: where P is the annual precipitation and PET is the potential evapo-transpiration) ranges between 0.03 and 0.2 at the north Delta (arid region), and less than 0.03 at the south (hyperarid region). In general, the distribution of the mean annual rainfall in this region shows a maximum close to the Mediterranean coast (190.8 mm/year at Rosetta) and then decreases rapidly toward the south. Most of the rain falls during winter ($\geq$ 80%), and only less 10% falls during spring.

Results of the annual water balance indicate that the drainage water contributes about 97 % (3.9 billion m^3), while rainfall contributes less than 2% (77.4 million m^3) and groundwater less than 1% of the total water resources in the lake ecosystem. On the other hand, evaporation losses represent about 16% of the total water resources in the lake (646.7 million m^3), while the drainage system discharges, about 3.2 billion m^3 to the sea through the lake (it represents, in addition to the change of storage in the reservoir, about 84% of the total water resources in this system).

Six major habitats are recognized in Burullus Wetland: salt marshes, sand formations, lake cuts, drains, the lake and islets. Salt marshes extend along the marine bar of Lake Burullus with an area approximates 40% of the total area of the bar (6% in the eastern part, and 34% in the western part). Three types of sand formations cover the surface of the marine bar of lake Burullus: sheets (or flats), hillocks and dunes. Lake cuts represent the recent lands that resulted after the drying process that took place along the shores of Lake Burullus, particularly the outermost western and eastern fringes. The drains, as a major habitat, were classified into four microhabitats (i.e. zones): terraces, slopes, water-edge and open water. The lake proper is classified into two habitats: lake shore and open water.

A total of 197 species of vascular plants have been recorded from Burullus Wetland (100 annuals and 97 perennials) including 11 hydrophytes (the most common is *Potamogeton pectinatus*) and one fern (*Azolla ficliculoides*). The most common of all these species is the common reed *Phragmites australis*. Some 226 algal species were recorded: 125 Bacillariophytes (Diatoms), 56 Chlorophytes, 39 Cyanophytes, 2 Euglenophytes, 2 Dinophytes, one cryptophyte, and one Rhodophyte. The zooplankton community of the lake was estimated as 90 species distributed as follows: 26 species of Copepoda, 7 of Cladocera, 26 of Rotifera, and 10 of Protozoa constitute collectively about 85% of the total zooplankton. The biotic community includes also 127 species of the terrestrial invertebrates, 25 species of fishes, 22 of reptiles, 112 of birds and 15 of mammals.

2- Water Properties

Water properties of Lake Burullus were evaluated during 2001 and 2004 in 15 stations representing the eastern, middle and western sectors of the lake. The estimated variables were classified into 4 main groups: physical and aggregate properties (air temperature, water temperature, transparency, depth, salinity, chlorosity, acidity and alkalinity), oxygen properties (dissolved oxygen, chemical and biological oxygen demands), dissolved salts (phosphate, nitrate, nitrite and silicate) and heavy metals (cupper, iron, cadmium, lead and zinc). The PCA ordination of the 15 stations based on their water properties indicates a clear separation between the stations of the eastern, middle and western sectors.

The annual mean of air and water temperatures were 22.9 and 22.3 °C, with spatial ranges among stations of 21.3-24.2 and 21.8-23.3 °C, and monthly ranges of 16.7-28.8 and 16.0- 29.4 °C. The annual means of water transparency and water depth were 31.0 and 115.8 cm, with spatial ranges of 22.3-49.6 and 80.8-195.3 cm, and monthly ranges of 25.3-40.0 and 110-133.3 cm. The annual mean of water salinity was 5.4 mS cm^{-1}, with spatial range of 1.6-16.8 mS cm^{-1}, and monthly range of 3.9-6.7 mS cm^{-1}. Chlorosity had the same trend of salinity with an annual mean of 1.9 g l^{-1}, spatial range of 0.6-6.6 g l^{-1} and monthly range of 1.3-2.3 g l^{-1}. Water in Lake Burullus is alkaline throughout the year. The annual mean of pH was 8.6, with a spatial range of 8.4-8.9 and a monthly range 8.0-9.2. On the other hand, the annual mean of alkalinity was 257.8 mg l^{-1}, with a spatial range of 188.0-309.6 mg l^{-1} and monthly range of 213.7-279.6 mg l^{-1}.

The annual mean of dissolved oxygen (DO), chemical (COD) and biological (BOD) oxygen demands were 8.2, 23.95 and 6.0 mg l^{-1}during 2004, respectively. The concentrations of dissolved salts had the following sequence: $SiO_3 > NO_3 > NO_2 > PO_4$, with annual means of 112.2, 43.8, 10.5 and 9.05 µg-at. l^{-1}.

The concentrations of heavy metals had the following sequence: Zn > Fe > Cu > Cd > Pb, with annual means of 8.5, 6.2, 5.9, 3.8 and 3.6 μg-at. l^{-1}. Generally, most of the estimated heavy metals of the water near to the southern shore were higher than those near the northern shore. In addition, the trend of variation along east-west axis was as follows: eastern sector > western sector > middle sector for all metals except Zn (east > middle > west). The spatial ranges in μg-at. l^{-1} were 3.5-17.2 (Zn), 1.9-13.7 (Fe), 2.6-8.8 (Cu), 1.6-8.4 (Cd) and 1.1-6.3 (Pb). On the other hand, the period extended from February to May had the peak of heavy metals increase, while the period from June to September had the reverse. The monthly ranges in μg-at. l^{-1} were 4.3-12.7 (Zn), 0.7-13.2 (Fe), 3.6-11.5 (Cu), 1.7-6.6 (Cd) and 1.2-6.2 (Pb).

The comparison of the dissolved salts in the water of Lake Burullus in 2001, with those of 1987 and 1997 indicated an increase of nitrate, nitrite and phosphate from 1987 to 1997, but a decrease in 2001. On the other hand, silicate had a decreasing pattern from 66.8 μg-at. l^{-1} in 1987 to 47.3 μg-at. l^{-1} in 1997 and 41.7 μg-at. l^{-1} in 2001. Regarding the heavy metals, there was a continuous increase in Cu, Zn, Pb and Cd contents from 1987 to 1997 and then to 2001. The correlation between salinity and chlorosity was significant positive. In addition, Cd and Zn had significant positive correlation with each other, on one hand, and with the salinity and chlorosity, on the other hand. This trend indicates that a considerable portion of the Cd and Zn in the water of Lake Burullus is due to the sea water (the main source for increasing water salinity in this lake). Phosphate, nitrate and nitrite, that used as fertilizers for the agricultural land in the catchment area of Lake Burullus, were positively correlated with each other (they are washed with the agricultural drainage into the lake). In addition Cu, Fe and Pb had significant positive correlations with each other on one hand, and with the previously mentioned dissolved salts on the other hand. This may indicate that the main source for pollution with these heavy metals are the agricultural drainage.

3- Sediment Properties

The bottom sediments along the northern shores extending from the lake-sea connection westwards, are mainly clayey- and silty-sand with some patches of molluscan shells. The eastern and western sites of the lake are silty-clay. The southern shore sediments, which receive directly the drain discharge, are mainly formed of clay and silt with small areas covered with molluscan shells. A significant reduction in sedimentation rates in Lake Burullus happened after approximately 1960. The trend of the pre-1960 biostratigraphic dates suggests that the first significant freshwater changes can be approximately dated to 1920. The pre-1960 sedimentation rate was calculated to be 0.32 g cm^{-2} yr^{-1} (3.9 mm yr^{-1}), which was significantly higher than the post-1960 value of 0.075 g cm^{-2} yr^{-1} (2.1 mm yr^{-1}).

The bottom sediments of Lake Burullus were collected from fifteen stations during winter (January) and summer (June) of 2000 and 2001. The samples were prepared to estimate the following properties: salinity, chlorisity, acidity, organic matter and heavy metals (Fe, Cu, Zn, Pb, Cd and Ni). Comparable to the PCA ordination of the same 15 stations based on the water properties, the PCA ordination based on sediment properties indicates a clear separation between the stations of the eastern, middle and western sectors of the lake.

The annual mean of sediment salinity was 2.0 mS cm^{-1} with a spatial annual range of 0.6 - 6.4 mS cm^{-1}. For both years of sampling (2000 and 2001), the salinity was higher in January (2.5 mS cm^{-1}) than June (1.6 mS cm^{-1}). The annual mean of chlorosity was 0.7 g l^{-1}, with a spatial range of 0.2 g l^{-1} - 2.1 g l^{-1}. Temporally, chlorosity had the same trend of salinity where it was higher in January (0.8 g l^{-1}) than June (0.7 g l^{-1}) due to the inflow of sea water to the lake winter months. The annual mean of pH was 7.8, with a range of 7.5 - 8.1. For both years of sampling, the mean of pH was higher in January (7.9) than in June (7.7). Regarding the organic matter, the annual mean was 2.8 %, with a spatial range of 0.8 - 5.6 %. In contrast with the properties, the mean of organic matter was lower in January (2.6 %) than in June (2.9 %).

The concentration of heavy metals in the lake sediments had the following sequence: Fe > Zn > Ni > Cu > Pb > Cd, with annual means of $16.2x10^3$, 58.9, 34.0, 22.9, 18.6 and 5.3 ppm, respectively. This trend is dissimilar to that of lake water (Zn > Fe > Cu > Cd > Pb). In addition, the trend of variation along east-west axis was: western sector > eastern sector > middle sector for all metals except Pb (east > west > middle) and Ni (west > middle > east). The spatial ranges in ppm were 2.7×10^3-35.1×10^3 (Fe), 22.2-119.7 (Zn), 3.3-72.5 (Ni), 8.9- 47.3 (Cu), 8.7- 54.8 (Pb) and 0.8- 45.9 (Cd). On the other hand, the sediments were characterized by higher contents of heavy metals in January than in June except Cd. The January-June ranges in ppm were 11.3×10^3-21.0×10^3 (Fe), 56.5-61.3 (Zn), 31.7-36.3 (Ni), 21.6-24.3 (Cu), 17.3-20.0 (Pb) and 2.7-7.9(Cd).

Similar to the water properties, the simple linear correlation coefficient between the sediment salinity and chlorosity was significant positive. On the other hand, and unlike to the water properties, the correlations between both variables and Zn are negative, although it does not reach the significant level in case of chlorosity with Zn. In addition to the previous correlations, organic matter had significant negative correlation with salinity and chlorosity, while the heavy metals Cu, Zn and Pb have significant positive correlations with each other. The smae water and sediment variables that had significant positive correlations were EC, Cl and Pb.

4- Flora and Vegetation

Burullus Wetland includes 10 types of habitat (sand formations, salt marshes, lake cuts, terraces, slopes, water edges and open waters of the drains, islets, shores and open waters of the lake). Each one of these habitats has some unique species (species solely found in one habitat). From the floristic biodiversity viewpoint, the most important habitats are the lake islets (26 unique species), sand formations and salt marshes (12 species for each of them).

The total number of the vascular plant species recorded in Burullus Wetland was 197 species (100 annuals and 97 perennials) belonging to 44 families and 139 genera. Twelve of these species are floated and submerged hydrophytes contributing about 6% of the total species. On the other hand, 34 species are woody plants contributing about 17.3 % of the total species (11 phanerophytes and 23 chamaephytes). Three species are endemic to Egypt (two annuals: *Sinapis arvensis* subsp. *allionii* and *Sonchus macrocarpus*, and: one perennial: *Zygophyllum album* var. *album*). Three other species are not found else where in Egypt except Nile Delta (*Ipomoea carnea, Vossia cuspidata* and *Ranunculus marginatus*). On the other hand, thirty-four species are rares allover Egypt (15 annuals and 19 perennials).

The application of Shannon diversity index, that evaluates the relative evenness of species dominance, indicated that Lake Burullus, which has the second largest area after Lake Manzala, had the highest species relative evenness of species, followed by Mariut, Manzala, Bardawil and Edku Lakes.

One hundred and forty one of the recorded species in Burullus Wetland (> 7.5 % of the total species) have at least one aspect of economic uses such as grazing, fuel, medicine, human food, timber and traditional industries. Ten species of them have at least 4 economic uses and could be considered as noteworthy multipurpose species.

The vegetation in the Burullus Wetland is classified into 13 vegetation groups (i.e. plant communities). Six groups are dominated or codominated with the common reed (*Phragmites australis*); these groups occupy a wide gradient from xeric to hydric habitats. Other five groups are dominated by halophytic species (*Arthrocnemum macrostachyum, Suaeda vera, Sarcocornia fruticosa, Halocnemum strobilaceum* and *Salsola kali*). The remaining two groups are dominated by the emergent *Typha domingensis* and submergant *Potamogeton pectinatus*.

From the floristic biodiversity viewpoint, we can conclude that the site of Burullus Wetland is considered as one of the richest sites in Egypt, taking into account its relatively small area (approximately 410 km^2). For example its flora

approximates 40% of the flora of the whole Nile Delta region that has an area of about 22,000 km^2, and exceeds those of many of the Egyptian nature reserves such as Nabq (600 km^2: 134 species) and Wadi Al-Allaqui (20,000 km^2: 92 species).

Globally Common reed (*Phragmites australis*) is believed to be the most widely distributed of all angiosperms. It is a perennial reed with broad and flat leaf blades and large terminal panicles. It reproduces from vegetative propagules and has a vigorous, branched rhizome system that runs quickly to new areas in either the submerged or dry lands. This plant threatens man's waterways, pastures and arable fields, but it can be a helpful companion. It provides shelter, material for thatching, food for animals, chemicals, fuel, fertilizer, biofilter, and raw material for paper making industry.

The trends of the estimation of standing crop phytomass (gm dry matter/m^2) of the above rhizome and above water shoots of this plant in Lake Burullus indicated higher values at the end of the season (in October), and at the east and south sides of the Lake comparing with the west and north sides. The analysis of Landsat TM images (1988 and 1998) indicated that the area of the Lake had decreased from 111608 feddan (=46876 ha) in 1988 to 100000 feddan (=42000 ha) in 1998 (reductions rate = 10.4 %). In the meantime, the area occupied by common reed had decreased from 24800 feddan (=10416 ha) to 16600 feddan (=6972 ha) which represents 16.6 % of the total area of the Lake (reduction rate = 33.1 %). The estimated maximum standing crop phytomass in the Lake as whole was 239040 ton dry matter: 170980 ton represents the above water standing crop, and 68060 ton represents the submerged portion.

The contents of organic and inorganic constituents and the calculated nutritive values of the green and dry parts of the shoots of the common reed indicated that the green parts is good or excellent fodder particularly during the spring season. Fortunately, microelements (i.e. heavy elements) have higher accumulation rate in the dry parts than in the green ones, and most of the estimated macro- and microelements are within the tolerable range in feeds commonly used in rations of sheep, goat and cattle.

The best way to control this plant is the deep ploughing followed by rotary hoaing using amphibian machines. The cutting below the water level is also efficient. However, if we take into account the analysis of Landsat images and the benefits of the common reed, it can be concluded that the infestation degree is not severe. But in some places, the reed infestation may be lead to the fragmentation of the lake into four disconnected basins: one at each of the outermost east and west sides, and two at the middle. Thus it is suggested to remove the reed from the narrow areas (as the case of the western side) and between the islets scattered in the Lake (as in the middle and eastern sides), and

to remove also the reed close to the south - eastern shores for at least 100 m inside the lake in order to stop the raising up of lake bed and to prevent its permanently connection with the land.

The ancient plant succession in Burullus Wetland may be happened as follows: before the time the soil at 30 m deep had been deposited, this region was part of the sea. After that, regression of the sea took place and the Nile water began to reach this area; xerophytes, hydrophytes and helophytes appeared and limited lagoons were formed. Nearly 20000 years ago, blocking of the Nile took place, but there was tremendous rainfall, on northern Egypt. Consequently, swamps covered by *Cyperus papyrus* had spreaded allover the area. Cold seasons probably followed, as indicated by the appearance of *Betula* and *Ulnus* pollen in the samples. After that, rainfall had decreased and swamps had limited, this was probably due to more deposition of transported matter by the Nile during erosion stage. Consequently, terrestrial plants began to flourish; and oscillations in the Nile run-off and the richness of the wild plants, with a rise in the sea level, took place. This was, probably, due to changes in solar radiation. The last picture was retreating of swamps and stabilization of land cultivation, as a result of continuous siltation.

5- Phytoplankton and Epiphytic Algae

The phytoplankton community of Lake Burullus is considered rich, both in density and species richness, but most of the species are fresh or brackish water forms. From the survey of the literature on phytoplankton assemblages of Lake Burullus, there is a large variation among the researchers in the species composition and density depending on the surveyed station, water depth, sampling season, water quality, environmental condition and water pollution of the lake. The summing up of all the recorded species in these studies in one checklist indicate the presence of 276 algal species distributed among the algal groups as follows: 142 species of Bacillariophyta (51.8 %), 73 species of Chlorophyta (26.0 %), 51 species of Cyanophyta (18.6 %) and 10 species of other groups (3.6 %).

Bacillariophytes (i.e. diatoms) represented the major bulk of the phytoplankton biomass (69.0% of its total biomass), although it ranked numerically as the second important group (31.1% of the total phytoplankton counts). On the other hand, Chlorophytes came in the second order in case of the biomass (16.2%), but in the first order regarding the density (58.9% of the total counts). Cyanophytes contributed 14.8% of the total biomass and 8.8% of the total counts. The other groups had a minor contribution. The highest phytoplankton biomass was recorded in the western sector of the lake and the lowest in the eastern sector.

The monthly fluctuations of the total phytoplankton biomass indicated that the maximum biomass was attained in early autumn (September) in the eastern and middle sectors. Relatively high values were also recorded during winter (February) in the eastern sector and spring (March) in the Middle sector. On the other hand, the highest biomass in the western sector was recorded during summer (June), beside smaller peaks in September and December. The temporal trend of the three major algal groups are quite similar.

Regarding the phytoplankton production, Lake Burullus tends to mesotrophy. This may be attributed to the decreased amount of drain water flowing into the lake, and the increased density of the submerged hydrophytes, particularly *Potamogeton pectinatus*.

The estimation of epiphytic algal communities growing on the hydrophytes in the Egyptian lakes is of prime importance in assessing their organic production. In Lake Burullus, *Potamogeton pectinatus* constituted about 85% of the total biomass of the submerged plants. The previous studies indicated the presence of 45 epiphytic species growing on this hydrophyte, most of them are limnetic forms, but can survive both planktonic and attached situations. These species are distributed among algal groups as follows: 27 Bacillariophytes (diatoms), 15 Chlorophytes, 12 Cyanophytes and 1 Rhodophyte.

The comparison between the phytoplankton communities of nine North African lakes (3 lakes in each of Egypt, Tunisia and Morraco), indicates that the three Egyptian lakes in Nile Delta (Manzalla, Burullus and Edku), which are alkaline sites with salinities less than 2 gm l^{-1}, are composed of cosmopolitan algal species and have larger density and more species diverse than the other lakes. Lake Burullus comes in the first regarding the density and diversity.

6- Bacteria and Fungi

The studies on the aquatic bacteria and fungi in Lake Burullus are limited. The distribution of some groups of actinomycetes in Lake Burullus was investigated seasonally during the year 2003. The diversity and counts of Streptomycetaceae, Actinoplanaceae and Nocardiopsaceae varied with the seasonal variation. Streptomycetaceae was the dominant group. The distribution of these groups was affected by some environmental factors such as temperature, organic matter and sediment nature. The diversity of zoosporic fungi from the surface water of four Egyptian lakes: Burullus and Manzala in the north, Qaron in the mid and Nasser in the south was studied in 2004. 36 species in addition to 4 unidentified species and only one variety belonging to 11 genera of zoosporic fungi were identified. Lake Burullus was the second most diverse lake (after Manzala), where 14 identified species, in addition to 3 unidentified species and one variety, were recorded.

7- Zooplankton

Lake Burullus has become more eutrophic and productive ecosystem during the last decade, due to the increasing amount of discharged drainage water, loaded with nutrients into the lake via the southern drains. At the same time, diversity of zooplankton species was sharply decreased, due to disappearance of marine species as a result of salinity decreasing and increasing of organic pollution.

During 2001/02, 48 zooplankton species belonging to 3 main groups (34 Rotifera, 7 Copepoda and 7 Cladocera) were recorded in Lake Burullus. There was no sign of the occurrence of all marine species (13 species) which have been previously recorded during the seventies of the last century. 18 zooplankton species (freshwater in origin) were recorded for the first time in the Lake during a recent survey in 2003/04. During this survey, 75 species of zooplankton were identified from the Lake; 39 rotiferan species, 15 copepods, 9 cladocerans, 8 protozoans and 4 meroplankton species.

Some marine species [(*Oithona nana. Paracalanus parvus, Euterpina acutifrons, Harpacticus* sp. and *Macrosrtella gracillis* (Copepoda) and *Eutintinnus lusus-undae, Metacylis mediterrnean* (Protozoa)] started to re-occur in the lake at the area near El-Boughaz, particularly during spring 2004. This was mainly due to the construction of two radial canals and clearing of El-Boughaz canal.

In general, the population density of zooplankton was obviously high in the western sector compared with the middle and eastern sectors. Regarding seasonal variation, there was a gradual increase in zooplankton standing crop from a minimum of 437,000 ind. m^{-3} in summer until reaching a maximum of 1,174,000 ind. m^{-3} in spring 2002, with an annual average of 667,000 ind. m^{-3}. The present standing crop of zooplankton is 6 times higher as compared with the situation in the seventies.

Rotifera is the most abundant group in all seasons and areas of the Lake, comprising 66.3% and 76.7% of total zooplankton in 2001/02 and 2003/04; while in 1978 and 1987/88 it was forming only 17% and 15.5 % of the total zooplankton, respectively. Copepoda was the second abundant group, forming 28.5 % of the total zooplankton density during 2001/02 and occupied the third position, contributing 9.2% of the total zooplankton crops in 2003/04.

Gut content analysis of adult fishes inhabiting lake Burullus revealed that Tilapia and mullets mainly feed on *Keratella quadrata* (zooplankton) and *Cyclotella* sp. (phytoplankton), so mass culture of these two species are highly recommended when establishing fish hatchery for the lake.

8- Macrobenthos

Different studies have revealed that Lake Burullus has become more dulcitude, eutrophic and productive ecosystem, owing to remarkable increase in amount of discharging agricultural drainage, loaded with nutrients, into the lake via the southern drains. Decreasing salinity and nutrients loading have led to a significant influence on biodiversity and abundance of benthos in Lake Burullus. The benthic communities are still subject to the evolutionary trend towards progressive dulcification and eutrophication promoting species, that prefer eutrophic habitats (tubificids and gastropods), which concurrently goes with disappearing of marine species.

Thirty three macrobenthic species, belonging to three main groups (Arthropoda, Annelida and Mollusca) were recorded in the Lake during 2002. There was no sign of occurrence of 8 marine species, which have been previously recorded in the Lake during the seventies and eighties of the last century. On the other hand, 17 species (freshwater in origin) were recorded for the first time in Lake Burullus during 2002.

9- Fishes and Fisheries

The occurrence of brackish and saline waters in Lake Burullus during seventies and early eighties of the last century, has resulted in a large variety of fish species inhabiting the Lake; approximately 32 species were recorded in the Lake during these periods. Decreasing of salinity and dominating of drainage water in the lake during the last two decades has led to change in species composition and biodiversity of fishes and other organisms. The field survey during 2000 – 2002 period showed that the diversity of fishes in Lake Burullus has declined from 32 to 25 species. All the species which have disappeared are of marine affinity. On the other hand, the total production of the lake has increased gradually from 7349 ton in 1963 to its maximum of 59000 ton in 2002. In the course of these forty years, a sharp decline in the total yield was recorded, especially in the middle of seventies, where the production declined to 4556 and 4875 ton in 1973 and 1974, respectively. Higher yields were regained in 1976 (6573 ton).

As far as the main groups of fishes are concerned, a gradual decrease in the mullet catch was recorded from about 44.7% in 1963 to 17% in 2000 of the total catch. This was accompanied by an increase of tilapia production from 42.8% in 1963 to 72% in 1992, and then decreased to about 67.8% in 2003. The shift was more pronounced during the eighties of the last centurry. On the other hand, the annual production of certain freshwater fish species has gradually increased, especially during the last five years. This relates to two species; *Clarias gariepinus* and *Bagrus bajad*, where their production increased from 188 and 220 ton in 1963 to 2150 and 744 ton in 2003, respectively. The

production of marine fishes, such as *Johnius hololepidotus* and *Dicenlrarchus labrax* was greatly decreased. All these changes confirm an increased predominance of freshwater components in the fish stock of the lake, reflecting the changes that the lake underwent in the water supply, mostly from drains, and reducing chlorosity of water, especially in the eastern part of the lake in association with the huge drains newely constructed at that area.

Cichlids are represented in Lake Burullus by four main species which are *Tilapia zillii, Sarotherodon galilaeus, Oreochromis niloticus* and *O. aureus*. Besides, there are two species of cichlids, namely *Hemichromis bimaculatus* and *Haplochromis bloyeti* but these are of little economic importance due to their small sizes. It was found that *Oreochromis niloticus* was the most abundant species in the 2002 catch, constituting more than 40.5 % of the total catch, followed by *Oreochromis aureus* (34.7 %), while *Sarotherodon galilaeus* was the least frequent species contributing 24.8 %. In the eastern sector, *Oreochromis aureus* is the most commonly distributed one (38.5 %) followed by *Sarotherodon galilaeus* (31.5 %), then *Oreochromis niloticus* (30.1 %). In the middle and western sector, *Oreochromis niloticus* is the major one with 39.8% and 53.6 %, respectively. *Oreochromis aureus* represents 35.7 and 28.9 %, whereas *Sarotherodon galilaeus* is the minorly distributed with 24.5 and 17.5 % in the two sectors, respectively.

On the other hand, five species of mullets are present in Lake Burullus namely: *Mugil cephalus*, *Liza ramada*, *Liza aurata*, *Liza saliens* and *Chelon labrosus*. *Liza ramada* is the most dominant species of the mullet catch throughout the year. Its accessibility in the nets operating in the lake greatly increases during November and December, when the fish is sexually ripe. *M. cephalus* production ranks next to that of *L. ramada.* Its maximum yield is attained during summer, representing maturation period. The fishery of *Liza saliens* whose production comes next to that of *M. cephalus* extends from late spring to the beginning of autumn. The maximum fishing of this species is recorded in September, during which the fish leaves the area of the lake-sea connection, where it is localized and migrates to the sea.

According to the statistical data, the number of fishermen has increased from about 9000 men in 1963 to about 21660 men in 1993, then to about 28,000 in 2002. The number of boats has increased from 2438 boats in 1963 to about 7277 in 1993 to 10489 boats in 2000. The annual catch per fisherman has been nearly doubled from about 0.8 ton in 1963 to about 2.0 ton in 1993, then decreased to about 0.9 ton in 2000. Likewise, the catch per boat has been doubled from about 3 ton in 1963 to about 6 ton in 1993, then decreased to about 5.3 ton in 2000. Statistical analysis of production functions revealed that the total catch of the lake is positively correlated with the total number of boats and

fishermen. This interdependence, between catch and fishing effort, is largely responsible for the variations in fish yields from year to year.

10- Arachnida and Insecta

Only 23 spiders and scorpions, belonging to 4 orders were recorded in Burullus Wetland during a short period study. Twenty spider species (Order Araneida), representing 9 families were recorded. Only one specimen of false scorpions (Order Pseudoscorpionida) belongs to family Olpiidae was collected. In addition, seven specimens of one species of scorpions (Order Scorpionida) *Androctonus amoreuxi* (family Buthidae) were collected, and also only one specimen of camel spiders (Order Solpugida) belongs to family Daesiidae was collected from Al-Kawm Al-Akhdar Islet.

On the other hand, 95 species belonging to 59 families and 16 orders were identified . No doubt, these data underestimate the insect fauna of the region due to the short period of this study (only 2 months). So, it is recommended to carry out an intensive and extensive study, based on monthly intervals, for a period of at least two continuous years, to get a real picture about the insect diversity of this region.

11 - Herpetofauna

Twenty three species of reptiles and amphibians have been reported from Burullus Protected Area, consisting of nine lizards, six snakes, two marine turtles and five amphibians . The herpetofauna is abundant and moderately diverse. The number of amphibian species and their relative abundance is notably high (five out of eight Egyptian amphibians), reflecting the availability of freshwater wetland habitats. The most common species are Bosc's Fringe-Toed Lizard *Acanthodactylus boskianus*, Egyptian Toad *Bufo regularis* and Mascarene Frog *Ptychadena mascareniensis*. The recently described Nile Valley Toad *Bufo kassasii* is an Egyptian endemic, found in localized, but dense populations in suitable freshwater swamps along the southern margins of the Protected Area. The species is thus far only known from Nile Valley in Egypt. It is not under any immediate threat, and is expanding its range in Egypt. Two globally threatened reptile species have been recorded in Burullus Protected Area; Loggerhead turtle *Caretta caretta* (Endangered) and Green turtle *Chelonia mydas* (Endangered). The Javelin Sand Boa *Eryx jaculus* is the most threatened species at the local level.

12- Birds

The bird surveys in Lake Burullus indicated the presence of 112 species and subspecies, which constitute about 22% of the total Egyptian avifauna. During four winter surveys (1978, 1979, 1989, 1994), there was a remarkable increase in species richness associated with a sharp decrease in the density of some populations. The sharp density decreasing was quite clear in case of Coot,

Shoveler, Black headed gull, Pochard and Ferruginus Duck. On the other hand, some other populations such as Kingfish Plover, Little Stint and Pied Kingfisher had an obvious increasing density.

Of the 112 birds recorded in Lake Burullus, 46 are residents, 80 are winter visitors, 23 are spring visitors and 72 are both summer and autumn passers. The collection of information about the national and world distributions of these birds indicated the possibility of occurrence of 8 endemic species and subspecies, which represent about 47% of the total endemic avifauna in Egypt.

Waterfowls are still being hunted allover the Egyptian wetlands, particularly Lake Burullus. This includes two types of hunting, commercial and sport hunting, both are practiced mainly during winter season where there is an abundance of wintering birds. The capturing of birds of prey, which practiced in the protected area, is the most destructive and less economically justifiable bird catching activity.

Many management practices are suggested to conserve the bird populations in Lake Burullus such as law enforcement in the protected area, carrying out public awareness programs about the importance of wildlife conservation in general, and that of avifauna in particular, encourage the activity of bird watching via ecotourism, preventing of habitat destruction or modification, establishing a program for protecting the threatened bird species and encourage the local organizations and NGO's to participate in the management of the protected area.

13- Mammals

A total of eighteen mammalian species, representing eleven families belonging to four orders, were recorded from Burullus Wetland. Rodents form the largest mammalian group of the area, being represented by seven species (about one-third of the total recorded species). Carnivores come next with five species. Insectivores and chiropterans were represented by only three species each.

Flower's Shrew *Crocidura floweri* is the only endemic mammal species known from Burullus Protected Area. The species is confined to the Egyptian Nile Valley, where it is very rare. The species was previously recorded from Wadi El Natrun in 1985. The only known record from Burullus area (Baltim) was from the 1930's. The Giant Musk Shrew *Crocidura flavescens* is the second rarest mammal in the Protected Area, where it is scarce. Three rodents are widely considered as pests because of the damage they cause to crops, these are: Black Rat *Rattus rattus*, Brown Rate *Rattus norvegicus* and House Mouse *Mus musculus*.

There are no globally endangered mammalian species recorded in Burullus Protected Area. In addition to the endemic Flower's Shrew *Crocidura floweri*, the

Jackal *Canis aureus* and Jungle Cat *Felis chaus* are locally threatened large carnivores.

14- Socioeconomic features

Kafr El Sheikh Governorate as a whole has a total population of 2319063 individuals (in 1999). Lake Burullus is located within five districts of the Governorate (from east to west: Baltim, El Hamoul, El Riad, Sidi Salem and Metobes), with a total population of 965220 individuals. Baltim district has the largest population around the Lake, mostly concentrated in Baltim city. The exact population number residing inside the Protected Area and their distribution is not yet known.

Fishing is the leading economic activity in the Protectorate and in Lake Burullus at large. Fish production from the Lake increased over the past two decades from just 7273 tons in 1982 to 53000 ton in 1996. It remains high with 55000 and 52000 ton in 1999 and 2000, respectively. The data on fish production for 2002 is about 59700 ton. The dramatic increase in the catch is the result of more intensive catching effort rather than a result of improved productivity. The catch composition clearly shifted from mainly marine species to fresh water species, particularly tilapia. In 1964 approximately 45% of the catch was tilapia, 25% shrimp and crab, 20% mullet and 10% catfish. This pattern changed in 1992 into nearly 72% tilapia, <10% shrimp and crab, 10% mullet and <10% catfish. In addition, the average size of the fish caught in the Lake has declined. In 1992, about 65% of the total catch of tilapia was categorized as small, 25% as medium and only 10% as large. Thus, although the total tonnage of fish caught in the Lake has grown over the past three decades, the value of the catch in terms of quality, size and revenue has declined.

The number of fishermen increased from about 9000 in 1963 to about 21600 in 1993. In 2000 there were approximately 28000 fishermen working on the Lake, of whom only 10266 were licensed. The number of licensed boats also increased from 2438 in 1963 to 7277 in 1993 and 10,439 in 2000. Of these, only 153 are motor boats and the rest are classified as third class boats of three types: the samboak (the smallest), the felouka (medium-sized) and the sailboat (the largest).

Agriculture is probably the second most important economic activity in Burullus Wetland. There are about 19000 Feddan under cultivation within the limits of the Protectorate. Agricultural activity in land close to the Lake shores is rather limited because of poor soil and high soil salinity. However, land reclamation efforts continue to be made on the western side of the inlet (Boughaz) where the soil is predominantly sandy. Agriculture in this area is mostly rain-fed. On the eastern side of the inlet, the area near Baltim is intensively cultivated (irrigated), mainly with date palms and guava. Other crops

include tomatoes, grapes, clover, cabbage, cauliflower, watermelons, broad beans, wheat, rice, and maize. In 1956, El-Hamoul Land Reclamation Project was initiated in the southern and southeastern regions of the Lake. However, land in this area is not easy to reclaim. In July 2000, the total area of farmlands in the 5 districts with parts inside the Protected Area was 292419 Feddan, of which about 19000 Feddan fell within the limits of the Protected Area.

Villagers inside the Protected Area breed buffaloes, cows, sheep and goats. The per capita net income of livestock seems to be relatively low. This can be attributed to the limited numbers of heads maintained by each family and the low productivity of the varieties involved. Inhabitants of the Burullus area regularly harvest *Phragmites australis* reeds as fodder for their livestock primarily utilizing the green shoots. Mature reeds are harvested and sold for LE 0.20 – 0.60 per bundle for a variety of uses, including mat making, wind breaks, as building material, fishing nets and bird catching.

Bird catching is a widespread activity in Burullus Wetland, and is largely concentrated in autumn (Quail catching) and winter (waterbird catching). Although all forms of hunting are now illegal after the declaration of Burullus as a protected area, it still continues. Quail catching is a traditional activity along the entire Egyptian Mediterranean coast, including Burullus. A variety of nets and traps, are used to catch Quail and other small birds during the autumn season. This activity is carried out largely on the sand bar. In winter catching targets waterbirds, which are caught using large nets or shotguns. The catch is usually transported to large towns and cities, such as Rosetta and even Alexandria where the birds fetch higher prices.

A modest tourist industry has existed for a long time in the Burullus area. It is based almost exclusively on Egyptian tourists attracted from the Nile Delta and Cairo during the summer months of June to mid-September. Most of this activity is concentrated in the seaside resort of Baltim. There are only about 164 hotel rooms in the entire Kafr El-Sheikh Governorate. Most of the summer holiday makers in Baltim stay in temporary rentals of chalets and apartments or in privately owned residences, which do not show in official statistics. Despite the diverse natural and cultural heritage of the region, the international tourism potential of the Burullus Wetland, and the Delta as a whole, has not been tapped. This is mostly due to the lack of awareness of the value of these resources and their potential to attract specialized tours.

Burullus Protected Area could have a good prospect as a specialized ecotourism attraction, particularly birdwatching. However, the lack of suitable facilities, and the presence of extensive bird catching activities during the primary birdwatching seasons (autumn and winter) are all important obstacles for the Protected Area's development as an international birdwatching attraction.

15- Management Plan

Surveys showed rich biodiversity of planktons, higher plants, and fauna including birds. The Lake is a wintering area of international importance for waterbirds. Biodiversity includes numbers of rare, endemic and threatened species. Fisheries provide the principal life-support system for the inhabitants: production approximates 51000 ton $year^{-1}$. Other resource uses include: agriculture, livestock farming, fish farming (about 155000 ton $year^{-1}$), reed harvesting, bird hunting, tourism and recreation.

The Lake and its surroundings are subject to ecological constraints that relate to excessive use of resources such as land reclamation, fish farming, over-fishing, over-hunting, and overwhelming flow for drainage water. Likely future constraints relate to impacts of new development projects, including: the international highway that runs along the sand bar, fishing port to the west of El-Boughaz, future sea-side resorts, etc. To this may be added the likely impacts of future climate change including sea-level rise.

The main long-term objectives of the present management plan include: 1- to restore pristine ecological and landscape values, 2- to maintain and enhance ecological and landscape values, 3- to conserve the Burullus resources through sustainable management, 4- to improve socio-economic opportunities for local people, and 5- to develop public awareness for nature conservation. The management plan aims at achieving the five main long-term objectives by 2010 through field actions (programmes and projects), and establishment of effective institutional arrangements. Six principal programmes could be implemented during the initial two years: five correspond to the 5 long-term objectives, and the sixth is to provide the administration and facilities to implement the plan. 13 projects under these six programmes are outlined, with total cost estimates of $ 5650000.

الملخص العربى

المقدمة

للأراضى الرطبة أهمية بيئية ترجع الى خصائصها المائية وكونها مناطق إنتقالية بين الأنظمة اليابسة والأنظمة المائية. وتوصف أحياناً بأنها كلى الأرض لأنها تؤدى وظيفة استقبال مياة الصرف والفضلات من المصادر الطبيعية والبشرية. والأراضى الرطبة معرضة حالياً إلى التحول إلى أراضى جافة تستخدم فى الزراعة وكمستقرات بشرية ، بالإضافة إلى أنشطة أخرى. تعرف الأراضى الرطبة ، ضمن تعريفات عديدة ، على أنها أنظمة بيئية تعتمد على الغمر الضحل بالماء وهذا الغمر قد يكون دائماً أو متقطعاً ، أو التشبع بالماء عند سطح التربة أو بالقرب منه. والصفات التشخيصية العامة للأراضى الرطبة هى أرض مبللة وكساء خضرى مائى.

تشمل منطقة البرلس الرطبة على إحدى البحيرات الخمس الموجودة شمال مصر، يحدها شمالاً البحر المتوسط وجنوباً الأراضى الزراعية شمال دلتا النيل. وهذه المنطقة هى إحدى مواقع الاتفاقية الدولية للأراضى الرطبة والمعروفة باسم اتفاقية رامسار، كما أنها اعلنت عام ١٩٩٨ كإحدى المحميات الطبيعية المصرية التى يديرها جهاز شئون البيئة المصرى. تمتد هذه البحيرة طولياً حوالى ٤٧ كم فى اتجاه شمال شرقى إلى جنوبى–غربى، ويتراوح عرضها ما بين ٥ إلى ١١ كم فى المتوسط، وعمقها ما بين ٤٠ إلى ٢٠٠ سم. وخلال القرنين الماضيين تقلصت مساحة البحيرة بنسبة تصل إلى ٦٢.٥٪ من مساحتها الأصلية (من ١٠٩٢ كم^{٢} عام ١٨٠١ إلى ٤١٠ كم^{٢} حالياً). تصل مساحة الحاجز الرملى الذى يفصل البحيرة عن البحر حوالى ١٦٥ كم^{٢}، ورغم أنه مفلطح نسبياً إلا أنه يحتوى على العديد من المواطن الهامة بعضها يرجع إلى تطور يعود إلى تطور ونمو عمليات الترسيب مثل المسطحات والكثبان والتلال الرملية ، وبعضها يعود إلى تغير مستوى سطح البحر مثل السبخات الملحية والمسطحات المدية.

تمثل القيعان القصبية ، والتى يسودها نبات البوص، فى بحيرة البرلس واحدة من أهم القيعان القصبية فى منطقة البحر المتوسط، حيث أن هذا الشكل من أشكال المواطن أصبح نادراً ومهدداً بالإنقراض. ومن المعلوم أن الطيور المقيمة والمهاجرة تعتمد بشدة على هذه المواطن فى الغذاء والملجأ والتكاثر. ومن الناحية الإقتصادية يعتبر الإنتاج السمكى هو النشاط البشرى الأساسى فى منطقة البرلس حيث يصل إلى حوالى ٥٢٠٠٠ طن سنوياً اعتماداً على ٢٨٠٠٠ صياد يستخدمون حوالى ٤٦٦٥ قارب. ومما يؤسف له أن هذه البحيرة، على الرغم من أهميتها البيئية والاقتصادية، تعتبر إحدى المناطق التى تستقبل مياة الصرف الزراعى (وأحياناً الصناعى والصحى) حيث يصلها حوالى ٤ بليون م^{٣} كل عام تشكل ٩٧٪ من كمية الماء الواصلة للبحيرة، وعلى الجانب الآخر تصرف البحيرة

حوالى ٨٠٪ من الكمية الواصلة اليها عن طريق البحر (من خلال بوغاز البرلس)، ١٦٪ عن طريق البخر.

كانت بحيرة البرلس موضع العديد من الدراسات والبحوث خلال العقود الثلاثة الماضية (١٩٧٠ – ٢٠٠٠) حيث نشر ما يزيد على ١٢٠ رسالة وتقرير وبحث (حسبما هو متوفر لدى المؤلفين) تتناول جيومورفولوجية وأبعاد البحيرة، والترسيب، والمياه ونوعيتها، والنباتات الكبيرة، والطافيات النباتية، والطافيات الحيوانية، وحيوانات القاع، والأسماك ومصايدها، والطيور وغيرها من الموضوعات الأخرى. وللأسف فإن العديد من هذه المواد العلمية إما قليلة التوزيع أو غير متاحة أو من الصعب الحصول عليها من قبل المتخصصين المهتمين بهذه الموضوعات. وقد شجع هذا الأمر المؤلفين على جمع وتنظيم وتحليل المعلومات والبيانات المتاحة، لكن المبعثرة، عن البحيرة، بالإضافة الى نتائج دراساتهم الخاصة الحديثة عن البحيرة، فى مؤلف واحد يتناول الخصائص الطبيعية والمكونات الحية بالإضافة إلى الأنشطة الاقتصادية والاجتماعية فى بحيرة البرلس، بحيث يصبح سهل المنال من قبل ذوى الشأن.

يحتوى هذا المؤلف على مقدمة وسرد تاريخى لمراجع، و١٣ باباً ينتهى كل منها بملخص وقائمة للمراجع، كما يوجد فى نهاية العديد من الأبواب لوحات تظهر الخصائص الطبيعية والأحيائية للبحيرة. يتناول الباب الأول الخصائص العامة للبحيرة مثل الموقع، والجيولوجيا، والجيومورفولوجيا، والأبعاد، وأنواع المواطن الأرضية، والمائية والمجتمع الأحيائى والمناخ. أما البابان الثانى والثالث فيتناولان التغيرات المكانية والزمانية فى خصائص رواسب وماء البحيرة. يهتم الباب الرابع بالنباتات والكساء الخضرى فى البحيرة والجزر التى بداخلها وكذلك المواطن المختلفة فى منطقة الحاجز الرملى. أما الباب الخامس فيشتمل على الطافيات النباتية من منظور تنوعها الحيوى وكثافتها وكتلتها الحية آخذين فى الاعتبار الأقسام الثلاثة الرئيسية للطافيات النباتية (الدياتومات والطحالب الخضراء والطحالب الزرقاء). وعلى الرغم من ندرة البحوث المتاحة عن البكتيريا والفطريات فى البحيرة، إلا أن الباب السادس قد خص لهذا الموضوع اعتماداً على نتائج بحثين حديثين اجريا على هذه الكائنات فى البحيرة.

يتناول الباب السابع والثامن الطافيات الحيوانية وحيوانات القاع والذى يقيم الوضع الحالى لهذه الكائنات فى البحيرة والتغيرات الموسمية للأنواع الشائعة منها. ولكون بحيرة البرلس إحدى المصايد السمكية الهامة فى مصر، فقد خصص الباب التاسع لهذا الموضوع ، والذى يشتمل على معلومات عن الأسماك الموجودة فى البحيرة وحرف الصيد والمخاطر التى تهدد هذه المصايد وتوصيات لدرء هذه المخاطر وتنمية المصايد. ويتناول الباب العاشر دراسة مجموعة العنكبيات لأول مرة فى محمية البرلس بالإضافة الى تنوع مجموعة الحشرات. أما الباب الحادى عشر فموضوعه البرمائيات والزواحف، بينما اهتم الباب الثانى عشر بالطيور المقيمة والمهاجرة مع التركيز على أهم مواطن

الطيور فى البحيرة وكذلك المسوح القديمة والحديثة التى أجريت على طيور البحيرة. أما الثدييات فكانت موضوع الباب الثالث عشر والذى يشتمل على قائمة بالأنواع الثديية الموجودة فى هذه المنطقة. اهتم الباب الرابع عشر بالتنمية الاقتصادية والاجتماعية فى منطقة البرلس، أما الباب الخامس عشر والأخير فقد تعرض لخطة الإدارة المقترحة لبحيرة البرلس وقد تم التركيز فى هذا الباب على الجزء من الخطة المتعلق بالتقييم والأهداف، والتنفيذ وخطة العمل، حيث أن الأجزاء الوصفية من الخطة قد تم تناولها بإسهاب فى الأبواب السابقة من هذا الكتاب.

ويأمل المؤلفون أن يكون هذا العمل مفيداً لصانعى القرار والمخططين والاقتصاديين والبيئيين وعلماء الصون البيئى والبحاث ، وطلبة العلوم الأحيائية والزراعية والاقتصادية.

١- الخصائص العامة

تقع منطقة البرلس الرطبة (محمية البرلس) على ساحل البحر المتوسط فى الجزء الشمالى من دلتا النيل. يحدها من الشمال ساحل البحر المتوسط ومن الجنوب الأراضى الزراعية لشمال دلتا النيل. تنتمى منطقة البرلس إدارياً إلى محافظة كفر الشيخ حيث توجد فى موضع وسط بين فرعى النيل: فرع دمياط شرقاً وفرع رشيد غرباً. تصل المساحة الكلية لمنطقة البرلس الرطبة (محمية البرلس) إلى حوالى ٤٦٠ كم^{٢} حيث تشتمل على كامل مساحة بحيرة البرلس وكذلك الحاجز الرملى الذى يفصل البحيرة عن البحر مع خط شاطئى طوله ٦٥ كم.

يأخذ الخط الشاطئى لبحيرة البرلس عدة أشكال تبعاً لنشأته. تأخذ البحيرة شكلاً مستطيلاً يمتد لمسافة ٤٧ كم على محور شمالى شرقى – جنوبى غربى. يتباين عرض البحيرة من الشمال إلى الجنوب من منطقة الى أخرى، ففى الجزء الغربى من البحيرة لا يزيد أقل عرض عن ٥ كم، ثم يزداد فى اتجاه الوسط ليصل الى حوالى ١١ كم. ومن الواضح أن بحيرة البرلس فقدت حوالى ٤٩٪ من مساحتها على مدار ١١٢ عاماً من ١٨٠١ (١٠٩٢ كم^{٢}) حتى ١٩١٣ (٥٥٦.٥ كم^{٢})، وحوالى ٦٢.٥٪ حتى عام ١٩٩٧ (٤١٠ كم^{٢}). تعتبر بحيرة البرلس بحيرة ضحلة بعمق يتراوح بين ٤٠ سم بالقرب من الشواطىء ، ٢٠٠ سم قرب فتحة البحر (بوغاز البرلس). دلت الدراسات الحقلية باستخدام تقنية الاستشعار عن بعد على أن أعمق المناطق فى البحيرة تقع فى القطاع الأوسط من البحيرة حيث يصل العمق الى ٢٠٠ سم، وأيضاً فى الأجزاء الجنوبية من القطاع الغربى (غرب جزيرة كوم دشيمى). يعتبر القطاع الشرقى هو الأكثر ضحالة حيث لا يزيد العمق عن ٢٠ سم بالقرب من الشاطىء، ولكنه يزداد ليصل الى ٧٠ سم.

ينقسم الحوض الرئيسى للبحيرة الى ثلاثة قطاعات: الشرقى، والأوسط والغربى، كل قطاع منهم له نوع من التجانس فى خصائصه الجيومورفولوجية ، والمائية والبيولوجية. تكون الجزر المبعثرة فى البحيرة فواصل طبيعية بين هذه القطاعات الثلاث.

الحاجز البحرى (الحاجز الرملى) لبحيرة البرلس هو المنطقة التــى تفصــل شــاطىء البحــر المتوسط فى الشمال عن شاطىء البحيرة فى الجنوب ويغطى مساحة قدرها ١٦٥ كم^{٢}. وبالرغم من أن سطح هذا الحاجز مسطح نسبياً ، لكن له مظاهر جيومورفولوجية متباينة، تكونت نتيجة تطــور ونمــو العمليات الجيومورفولوجية. بعض هذه المظاهر يعود الى عملية الترسيب مثل المســطحات والكثبــان والتلال الرملية ، والبعض الآخر يعود إلى تغير مســتوى ســطح البحــر مثــل الســبخات الملحيــة والمسطحات المدية.

يوجد العديد من الجزر المبعثرة داخل بحيرة البرلس، وبســبب تواصــل تــأثيرات العمليــات الجيومورفولوجية (الترسيب والتعرية وفيضان الماء) ، فإن عدد وحجم وأبعاد وأماكن هذه الجزر يتغير من وقت إلى آخر. فهى تتحرك من أماكنها أو تلتحم ببعضها حينما تكون قريبة. يصل العــدد الحــالى لهذه الجزر إلى ثلاثين جزيرة تأخذ عدة أشكال منها المستطيل (جزيرة دبيار)، والدائرى أو البيضاوى (جزيرة الزنقة)، والمثلث (كوم دشيمى)، والقوس (جزيرة شيشة العجوزة).

طبقاً لخريطة التوزيع العالمى للمناطق الجافة، ينتمى الجزء الشمالى من منطقة دلتــا النيــل ، والذى توجد به منطقة البرلس، إلى منطقة البحر المتوسط الجافة. الأحوال المناخية هى صيف دافــىء (٢٠ – ٣٠ °م)، وشتاء معتدل (١٠ – ٢٠ °م). يتراوح معامل الجفافية (المطر السنوى : البخر – نتح السنوى المدخر) بين ٠.٠٠٣ ، ٠.٢ بالقرب من ساحل البحر (منطقة جافة)، وأقــل مــن ٠.٠٠٣ فــى الجنوب (منطقة شديدة الجفاف). وعموماً فإن كمية المطر السنوى تصل إلى حــوالى ١٩٠ مــم عنــد رشيد، وتتقص بشدة فى اتجاه الجنوب. معظم المطر يسقط خلال الشتاء (أكبر من ٨٠٪)، وحوالى أقل من ١٠٪ يسقط خلال الربيع.

تدل نتائج الميزان المائى فى البحيرة على أن ماء الصرف يشكل ٩٧٪ من المصادر المائيــة الكلية للبحيرة (٣.٩ بليون م^{٣})، بينما يشكل المطر أقل من ٢٪ (٧٧.٤ مليون م^{٣})، والميــاة الجوفيــة أقل من ١٪. وعلى الجانب الآخر يمثل البخــر فقــداً قــدرة ١٦٪ مــن المصــادر المائيــة الكليــة (٦٤٦.٧ مليون م^{٣})، والماءالمنصرف الى البحر يشكل حوالى ٨٤٪ من المصــادر المائيــة الكليــة (٣.٢ بليون م^{٣}).

يوجد فى منطقة البرلس الرطبة ست مواطن رئيسية هى: السبخات الملحية، والتكوينات الرملية (المسطحات والتلال والكثبان الرملية)، وطرح البحيرة (وهى الأراضى الناتجة عن عمليــات تجفيــف البحيرة والتى تقع بصفة خاصة فى أقصى الجزء الشرقى والغربى من البحيرة)، والمصارف (جســر ومنحدر وحافة وماء المصارف)، والبحيرة (شواطىء البحيرة والماء المفتوح) والجزر. ويتميــز كــل موطن من هذه المواطن بخصائص طبيعية وكيماوية تميزه عن غيرة من المواطن.

يتمثل المجتمع الأحيائى فى منطقة البرلس من المنظور الوظيفى للنظام البيئى بثلاثــة أقســام أساسية وهى الكائنات المنتجة والكائنات المستهلكة والكائنات الرمية. تمثل الكائنات المنتجة بالنباتــات

الوعائية الجذرية والطافيات النباتية. يوجد بالمنطقة حوالى ١٩٧ نباتاً وعائياً (١٠٠ نبات حولى + ٩٧ نبات معمر) تشمل على ١١ نبات مائى (أشهرها نبات ديل الغراب) وسرخس واحد (سرخس الماء). والنبات الأكثر انتشاراً فى هذه المنطقة هو نبات البوص. تتمثل الطافيات النباتية بحوالى ٢٣٣ نوعاً طحلبياً موزعة كالتالى: ١٢٤ نوعاً من الدياتومات، ٥٩ من الطحالب الخضراء، ٣٩ من الطحالب الزرقاء، ٢ من اليوجلينات، ٢ من الطحالب النارية وطحلب أحمر. تتكون الطافيات الحيوانية من ٩٠ نوعاً، واللافقاريات الأرضية من ١٢٧ نوعاً (ولكن هذا العدد لا يعكس الموجود بدقة حيث أن هذه المجموعة لم تدرس بشكل مستفيض). يوجد أيضاً ٢٥ نوعاً من الأسماك ٢٢ نوعاً من الزواحف ، ١١٢ نوعاً من الطيور و ١٤ نوعاً من الثدييات.

درست استجابات بحيرة البرلس الحيوية للتغيرات البيئية الحديثة باستخدام ثقب فى قاع البحيرة عمقه ١ م ، والذى عادة ما يعكس التغيرات على مدار مائة عام ماضية. قسم هذا الثقب إلى ثلاثة نطاقات. دل الوجود المكثف لحبوب لقاح الفصيلة الزربيحية وبذور نبات الخريزة فى النطاق الأول (العمق أكبر من ٣٦ سم) على انتشار السبخات الملحية. ويعتقد أن مستوى سطح الماء كان منخفضاً قبل عام ١٩٠٠، مما أدى انتشار هذه السبخات. تدل البقايا الحيوانية فى هذا النطاق الى افتراض أن الماء كان عذباً أو مختلطاً، مع وجود فترات دورية لغزو ماء البحر للبحيرة. وفى النطاق الثانى (١٦ – ٣٦ سم)، لوحظ وجود نقص واضح فى حفريات الكائنات التى تقطن السبخات القصبية والملحية وكذلك فى حيوانات المياه العذبة. وبالرغم من ذلك، فإن تسجيلات حبوب اللقاح تدل على زيادة موضعية فى الكساء الخضرى للسبخات الملحية. وقد انتشرت بعد ذلك النباتات المائية المتأقلمة مع المياه المختلطة، إلا أنه من المحتمل أن مجتمع المياه المختلطة قد تقلص بعد عام ١٩٢٠. وفى عام ١٩٤٠ على وجه التقريب (النطاق ٣أ: ٨–١٦ سم)، يعتقد أن تأثير المياه العذبة كان كبيراً والدليل على ذلك انتشار رخويات وحيوانات المياه العذبة. وفى النطاق ٣ب (<٨ سم)، والذى بدأ فى ١٩٦٣، زاد تأثير المياه العذبة، ويتطابق هذا مع استكمال مشروع السد العالى. وبعد ذلك، غزا البحيرة النبات المائى المغمور المسمى ديل الفرس والذى ينتشر فى البحيرة الآن بغزارة. استمرت سبخات البردى فى الإنتشار بالقرب من منطقة الثقب وزادت حيوانات المياه العذبة، بينما انخفضت كائنات المياه المختلطة. ومع ذلك ، فإن التغيرات الحديثة فى بحيرة البرلس تعتبر قليلة مقارنة بالعديد من بحيرات شمال افريقيا ويرجع ذلك إلى أن مستوى الملوحة فى بحيرة البرلس ما زال مصاناً نسبياً.

٢– خصائص الماء

تم تقييم خصائص ماء بحيرة البرلس بناءاً على رصد شهرى لمدة عام كامل (يناير – ديسمبر ٢٠٠١) لخمس عشرة محطة موزعة على القطاعات الثلاثة للبحيرة (الشرقى والأوسط والغربى). بالإضافة الى دراسة حديثة تمت عام ٢٠٠٤ من خلال البرنامج الرصدى لمشروع صيانة الأراضى

الرطبة بحوض البحر المتوسط. قسمت الخصائص العشرين التى تم دراستها إلى أربعة مجموعات: الخصائص الطبيعية والتجميعية (حرارة الهواء والماء، الشفافية وعمق الماء، الملوحة والكلورة، الحموضة والقلوية)، الخصائص الأكسيجينية (الأكسجين الذائب، الأكسجين الكيماوى والحيوى المستهلك)، الأملاح الذائبة (الفوسفات، النترات، النيتريت، السليكات)، المعادن الثقيلة (النحاس، الحديد، الكادميوم، الرصاص والزنك). وقد أوضحت عملية تنسيق المحطات باستخدام تحليل المكون الأساسى، وبناءاً على خصائص مائها، فصلاً ما بين محطات القطاع الشرقى والأوسط والغربى.

كان المتوسط السنوى لحرارة الهواء والماء قرب سطح ماء البحيرة ٢٢.٥ و ٢٣.٣ °م على التتابع. وكان التباين المكانى بين المحطات المختلفة هو ٢١.٣ – ٢٤.٢ °م لحرارة الهواء، و ٢١.٨ – ٢٣.٣ °م لحرارة الماء ، أما التباين الشهرى فكان كالآتى: ١٦.٧– ٢٨ °م لحرارة الهواء، و ١٦.٥ – ٢٩.٤ °م لحرارة الماء. أما عن شفافية وعمق الماء فكان المتوسط السنوى ٣١.٥ و ١١٥.٨ سم، على التتابع؛ وتراوح التباين المكانى بين ٢٢.٣ إلى ٤٩.٦ سم للشفافية، و ٨٠.٨ – ١٩٥.٣ سم لعمق الماء؛ والتباين الشهرى بين ٢٥.٣ – ٤٠ سم للشفافية، و ١١٠–١٣٣.٣ سم للغمق. كان المتوسط السنوى للملوحة ٥.٤ ملليسيمنز سم$^{-1}$ ، والمدى المكانى ١.٦ – ١٦.٨ ملليسيمنز سم$^{-1}$ ، والمدى الشهرى ٣.٩ – ٦.٧ ملليسيمنز سم$^{-1}$. أما المتوسط السنوى للكلور فكان ١.٩جرام لتر$^{-1}$، بتباين مكانى قدره ٠.٦ – ٦.٦ جرام لتر$^{-1}$، وتباين زمانى قدره ١.٣ – ٢.٣ جرام لتر$^{-1}$. يميل ماء بحيرة البرلس إلى القلوية طوال العام حيث أن المتوسط السنوى للرقم الهيدروجينى ٨.٦ بتباين مكانى قدره ٨.٤ –٨.٩ ، وتباين شهرى قدره ٨.٠ – ٩.٢. أما عن القلوية فكان المتوسط السنوى ٢٥٧.٨ مجم لتر$^{-1}$، بتباين مكانى قدره ١٨٨.٠ – ٣٠٩.٦ مجم لتر$^{-1}$، وتباين شهرى قدره ٢١٣.٧–٢٧٩.٦ مجم لتر$^{-1}$.

بلغت المتوسطات السنوية للأكسجين الذائب والكيماوى المستهلك والحيوى المستهلك ٨.٢ ، ٢٣.٩٥ ، ٦.٠، على التتابع. وتترسب الأملاح الذائبة حسب تركيزها فى ماء البحيرة كما يلى: سليكات > نترات> نيتريت > فوسفات بمتوسطات سنوية قدرها ١١٢.٢ ، ٤٣.٨ ، ١٠.٥ ، ٩.٠٥ ميكروجرام ذرى لتر$^{-1}$، على التتابع.

تتدرج العناصر الثقيلة حسب تركيزها فى ماء البحيرة كما يلى: زنك > حديد > نحاس > كادميوم > رصاص بمتوسطات سنوية قدرها ٨.٥ ، ٦.٢ ، ٥.٩ ، ٣.٨ ، ٣.٦ ميكروجرام ذرى لتر$^{-1}$، على التوالى. وعموماً فإن تركيزات معظم العناصر الثقيلة كانت أعلى بالقرب من الشاطىء الجنوبى عنها بالقرب من الشاطىء الشمالى. وبالإضافة إلى ذلك، كان اتجاه التغير من الشرق إلى الغرب كما يلى: الشرق > الغرب > الوسط لكل العناصر عدا الزنك (شرق > وسط > غرب)، وكان مدى التباين المكانى كما يلى: ٣.٥ – ١٧.٢ ، ١.٩ – ١٣.٧ ، ٢.٦ – ٨.٨ ، ١.٦ – ٨.٤ ، و ١.١ – ٦.٣ ميكروجرام ذرى لتر$^{-1}$، على التوالى. وبالنسبة للتباين الشهرى تميزت الفترة من فبراير حتى

مايو بتركيزات عالية من كل العناصر ؛ بينما تميزت الفترة من يونيو حتى سبتمبر بتركيزات منخفضة ، وكان مدى التباين الشهرى لهذه العناصر كما يلى: ٤.٣ – ١٢.٧ ، ٠.٧ – ١٣.٢ ، ٣.٦ – ١١.٥ ، ١.٧ – ٦.٦ ، و ١.٢ – ٦.٢ ميكروجرام ذرى لتر$^{-1}$، على التوالى.

وبمقارنة الأملاح الذائبة المقدرة عام ٢٠٠١ و٢٠٠٤ بتلك المقدرة عامى ١٩٨٧ و١٩٩٧، لوحظ زيادة تركيزات النترات والنيتريت والفوسفات من ١٩٨٧ الى ١٩٩٧ ثم انخفضت عام ٢٠٠١وزادت مرة اخرى عام ٢٠٠٤. وفيما يخص السليكات فقد انخفض تركيزه من عام ١٩٨٧ الى عام ١٩٩٧ وعام ٢٠٠١ ثم زادت عام ٢٠٠٤ (٦٦.٨ ، ٤٧.٣ ، ٤١.٧ و ١١٢.٢ ميكروجرام ذرى لتر$^{-1}$، على التوالى). أما عن المعادن الثقيلة فكان هناك زيادة مطردة من ١٩٨٧ إلى ١٩٩٧ ثم إلى ٢٠٠١. ونتيجة لحساب معامل الإرتباط الخطى البسيط بين خصائص الماء، اتضح أن العلاقة بين الملوحة والكلورة معنوية موجبة ، والعلاقة بين الكادميوم والزنك معنوية موجبة أيضاً ، والعلاقة بين الملوحة والكلورة من جانب والكادميوم والزنك من جانب آخر معنوية موجبة، مما يدل على أن كمية لابأس بها من الكادميوم والزنك مصدرها ماء البحر (الذى يعتبر المسبب الرئيسى لزيادة الملوحة والكلورة فى مياه البحيرة). أوضحت نتائج تحليل الإرتباط الخطى البسيط أيضاً أن الأملاح الذائبة: النترات والنيتريت والفوسفات بينها علاقة معنوية موجبة، وكذلك العلاقة بين النحاس والحديد والرصاص ، كما أن العلاقة بين هذه العناصر الثقيلة من جانب وتلك الأملاح الذائبة من جانب آخر علاقة معنوية موجبة ، مما يدل على أن التلوث بهذه العناصر الثقيلة سببه ، ولو جزئياً ، مياه الصرف الزراعى التى تصب جنوب البحيرة والتى تحتوى على كمية كبيرة من هذه الأملاح الذائبة التى تستخدم فى تخصيب الأراضى الزراعية.

٣- خصائص الرواسب

يتكون قاع البحيرة على الشاطىء الشمالى الممتد من منطقة اتصال البحيرة بالبحر المتوسط فى اتجاه الغرب من رواسب رملية طينية ، ورملية طميية مع وجود بعض الرقع المغطاة برواسب الأصداف الرخوية. أما المنطقة الشرقية والغربية للبحيرة فإن رواسبها طينية طميية ، والمنطقة الجنوبية التى تستقبل مباشرة مياه الصرف القادمة من المصارف فغالباً تتكون رواسبها من الطين والطمى مع وجود بعض المناطق المغطاة بأصداف الرخويات. وبالإضافة إلى ذلك، دلت الدراسات الحديثة على حدوث نقص ملحوظ فى عملية الترسيب داخل البحيرة بعد عام ١٩٦٠ تقريباً ؛ حيث أن دراسة اتجاه تاريخ الطبقات الرسوبية يدل على أن أول تغيرات هامة فى مياه البحيرة حدث عام ١٩٢٠. وتم تقدير معدل الترسيب قبل عام ١٩٦٠ بحوالى ٠.٣٢ جرام سم$^{-2}$ سنة$^{-1}$ (٣.٩ جرام سنة$^{-1}$) ، والذى يعتبر أعلى من معدل الترسيب بعد ١٩٦٠ والذى بلغ ٠.٠٧٥ جرام سم$^{-2}$ سنة$^{-1}$ (٢.١ جرام سنة$^{-1}$).

جمعت عينات رواسب قاع البحيرة من ١٥ محطة خلال فصلى الشتاء (ينـاير) والصيف (يونيو) عامى ٢٠٠٠ ، و٢٠٠١. وقد اعدت العينات لتقدير الخصائص التالية: الملوحة ، الكلورة، الحموضة، المادة العضوية، العناصر الثقيلة (حديد، نحاس، زنك، رصاص، كادميوم، ونيكل). واتساقاً مع نتيجة تحليل المكون الأساسى للمحطات الخمس عشرة بناءاً على خصائص مائها، فإن نتيجة نفس التحليل بناءاً على خصائص الرواسب ادت أيضاً على فصل مقبول بين محطات القطاع الشرقى والأوسط والغربى.

بلغ المتوسط السنوى للملوحة ٢ ملليسيمنز سم$^{-1}$ ، مع تباين مكانى قدره ٠.٦ – ٦.٤ ملليسيمنز سم$^{-1}$ ، كما كانت الملوحة فى يناير (٢.٥ ملليسيمنز سم$^{-1}$) أعلى منها فى يونيو (١.٦ ملليسيمنز سم$^{-1}$). أما عن الكلورة فقد بلغ المتوسط السنوى ٠.٧ جرام لتر$^{-1}$، مع تباين مكانى قدره ٠.٢ – ٢.١ جرام لتر$^{-1}$. وتشابهاً مع الملوحة كانت الكلورة فى يناير (٠.٨ ميلجرام لتر$^{-1}$) أعلى منها فى يونيو (٠.٧ جرام لتر$^{-1}$) ويرجع ذلك إلى أن ماء البحر يدخل البحيرة فى شهر يناير غالباً. بلغ المتوسط السنوى للرقم الهيدروجينى ٧.٨ بمدى مكانى قدره ٧.٥ – ٨.١، وكان المتوسط خلال يناير (٧.٩) أعلى منه خلال يونيو (٧.٧). أما عن المادة العضوية فقد بلغ المتوسط السنوى ٢.٨٪ مع تباين مكانى قدره ٠.٨ – ٥.٦٪. وعلى العكس من الخصائص السابقة، كانت المادة العضوية فى يناير (٢.٦٪) أقل منها فى يونيو (٢.٩٪).

تتدرج العناصر الثقيلة حسب تركيزها فى رواسب البحيرة كما يلى: حديد > زنك > نيكل > نحاس > رصاص > كادميوم بمتوسطات سنوية قدرها ١٦.٢ × ١٠^{٣}، ٥٨.٩، ٣٤.٠، ٢٢.٩، ١٨.٦، و٥.٣ جزء فى المليون، على التوالى. ومن الجدير بالذكر الإشارة إلى أن تدرج العناصر الثقيلة فى الماء يختلف عنه فى الرواسب (زنك > حديد > نحاس > كادميوم > رصاص). بالإضافة إلى ذلك فإن تدرج التغير فى التركيز حسب القطاعات كان كما يلى: الغرب > الشرق > الوسط لكل العناصر عدا الرصاص (الشرق > الغرب > الوسط) والنيكل (الغرب > الوسط > الشرق). وتراوح المدى المكانى كما يلى: ٢.٧ × ١٠^{٣} – ٢١.٠ × ١٠^{٣} (حديد)، ٢٢.٢ – ١١٩.٧ (زنك)، ٣.٣ – ٧٢.٣ (نيكل)، ٨.٩ – ٤٧.٣ (نحاس)، ٨.٥ – ٥٤.٨ (رصاص)، و ٠.٨ – ٤٥.٩ (كادميوم) جزء فى المليون. وزمانياً تتميز شهر يناير بمتوسطات عالية من كل العناصر مقارنة بشهر يونيو ما عدا الكادميوم حيث أن العكس هو الصحيح. كان مدى التغير من شهر يناير الى يونيو مقدراً كجزء فى المليون كما يلى: ١١.٣ × ١٠^{٣} – ٢١.٠ × ١٠^{٣} (حديد)، ٥٦.٥ – ٦١.٣ (زنك)، ٣١.٥ – ٣٦.٣ (نيكل)، ٢١.٦ – ٢٤.٣ (نحاس)، ٢.٧ – ٥٤.٨ (رصاص)، و ٢.٧ – ٧.٩ (كادميوم).

وتشابهاً مع خصائص الماء، كان معامل الإرتباط البسيط بين الملوحة والكلورة فى الرواسب معنوياً موجباً. وعلى العكس من خصائص الماء ، كان الإرتباط بين هاتين الخاصيتين من جانب

والزنك من جانب آخر سالباً، الا أنه لم يصل إلى مستوى المعنوية فى حالة الكلور مع الزنك. بالإضافة إلى ذلك، كانت العلاقة بين المادة العضوية من جانب، والملوحة والكلورة من جانب آخر معنوية سالبة، بينما العلاقة بين كل من النحاس والزنك والرصاص معنوية موجبة. أما العناصر المتماثلة فى الماء والرواسب التى لها علاقات معنوية موجبة مع بعضها فكانت الملوحة والكلور والرصاص.

٤- النباتات والكساء الخضرى

تحتوى منطقة البرلس على عشرة مواطن رئيسية يتميز كل موطن منها باحتوائه على عدد من الأنواع النباتية الفريدة التى لا توجد فى هذه المنطقة إلا فيه، وهذه المواطن هى: السبخات الملحية، والتكوينات الرملية ، وطرح البحيرة ، وجسور ومنحدرات وحواف وماء المصارف)، والجزر، وشاطىء وماء البحيرة . ومن وجهة نظر التنوع النباتى تعتبر الجزر (٢٦ نوعاً فريداً)، والتكوينات الرملية (١٢ نوع)، والسبخات الملحية (١٢ نوع) هى المواطن الأكثر أهمية.

يقدر العدد الكلى للنباتات الوعائية الموجودة فى منطقة البرلس بحوالى ١٩٧ نوعاً (منها ١٠٠ نوع حولى و ٩٧ نوع معمر) تنتمى الى ٤٤ فصيلة، ١٣٩ جنساً. يقدر عدد الأنواع المائية الطافية والمغمورة بحوالى ١٢ نوعاً تشكل ٦٪ من العدد الكلى للأنواع، وعلى الجانب الآخر فإنه يوجد ٣٤ نوعاً خشبياً (شجيرات وأشجار) تشكل ١٧.٣٪ من العدد الكلى للأنواع.

يوجد بالمنطقة أيضاً ٣ أنواع متوطنة: نوعان حوليان (وهما خردل وجلاوين)، ونوع معمر (وهو رطريط)، كما يوجد ٣ أنواع أخرى لا توجد على على المستوى القومى إلا فى منطقة دلتا النيل (مشتملة على منطقة البرلس التى توجد فى شمال الدلتا) وهى ايبوميا، فوسيا وشقيق. يوجد أيضاً ٣٤ نوعاً نادراً على المستوى القومى منها ١٥ نوع حولى و ١٩ نوع معمر. ومن الناحية الاقتصادية فإنه يوجد ١٤١ نوعاً تشكل ٧١.٥٪ من العدد الكلى للأنواع لكل منها أهمية اقتصادية واحدة على الأقل مثل الرعى، والوقود، والطب الشعبى، والغذاء الآدمى، الخشب، والاستخدامات الصناعية التقليدية. ومن هذه الأنواع الهامة اقتصادياً يوجد عشرة أنواع ذات استخدامات اقتصادية متعددة (أربعة استخدامات فأكثر)، ولذا فإنها تعتبر من الأنواع الجديرة بالاهتمام والمتابعة. ومن الجدير بالذكر الإشارة إلى الكساء الخضرى لبحيرة البرلس يتميز بأعلى وفرة نوعية وانتظام نسبى مقارنة بالبحيرات الأخرى فى شمال مصر (مريوط ، المنزلة ، ادكو والبردويل).

ينقسم الكساء الخضرى فى منطقة البرلس الى ١٣ مجموعة نباتية: ست منها يسودها، او يشارك السيادة مع آخرين، نبات البوص وهذه المجموعات تحتل تدرجاً بيئياً واسعاً يمتد من المواطن الجافة على جسور المصارف الى منطقة الماء المفتوح داخل البحيرة والمصارف.تسود خمس مجموعات أخرى نباتات محبة للملوحة حيث تقطن مواطن السبخات الملحية (وهى شنان، سبطة، أبو

سامة، حطب حدادى، واشنان). أما المجموعتان الباقيتان فيسودهما نباتات مائية (وهى النبات المنبثق "بردى" والنبات المغمور "ديل الفرس").

ومن وجهة نظر التنوع الحيوى النباتى، يمكن اعتبار منطقة البرلس واحدة من أكبر المناطق تنوعاً فى مصر آخذين فى الاعتبار مساحتها الصغيرة نسبياً (حوالى ٤١٠ كم^٢). فعلى سبيل المثال تشكل فلورة هذه المنطقة حوالى ٤٠٪ من فلورة منطقة الدلتا كلها والبالغ مساحتها حوالى ٢٢ الف كم^٢)، وتزيد عن فلورة بعض المحميات كبيرة الحجم مثل وادى العلاقى (٢٠٠٠٠ كم^٢ و ٩٢ نوع) ونبق (٦٠٠ كم^٢ و ١٣٤ نوع).

تحتاج استراتيجية الإدارة المستدامة للتنوع الحيوى على وجه العموم، والتنوع النباتى على وجه الخصوص فى منطقة البرلس، الى تطبيق بعض الإجراءات الهامة مثل وقف التأثيرات البشرية الخطيرة التى تؤدى تدريجياً فى بعض الأحوال، وفجأة فى البعض الاخر، الى انقراض بعض الجماعات النباتية، وبالتالى تحوير المجتمعات النباتية المركبة الى مجتمعات بسيطة هشة لا تقوى على البقاء لمدة طويلة. تتمثل التأثيرات البشرية الضارة فى هذه المنطقة فى مواصلة استصلاح الأراضى على حساب الكساء الخضرى الطبيعى وخاصة فى التكوينات الرملية والسبخات الملحية، تغير خصائص ماء البحيرة بسبب التفريغ الزائد لمياة الصرف الزراعى والصناعى والبشرى، تجزؤ وحتى إزالة المواطن الطبيعية خاصة التكوينات الرملية والسبخات الملحية الموجودة فى منطقة الحاجز الرملى وبعض الجزر.

ومن المهم أيضاً تنظيم عملية إزالة البوص بالقرب من مصبات المصارف وشواطىء البحيرة والممرات التى بين الجزر، مع ربط كتل الماء بقنوات تعمل على تسريع حركة الماء ومنع تجزئة البحيرة. يجب أيضاً الإهتمام برفع الوعى الشعبى للسكان المحليين حول الدور الذى تقوم به منطقة البرلس الرطبة كمحمية طبيعية للمئات من الكائنات الحية، ومدى ترابط ذلك بالإستخدام المستدام لمواردها مما يعود على سكان المنطقة بالنفع على المدى الطويل. يمكن أن تشمل برامج التوعية على إقامة دورات تدريبية، ومحاضرات عامة، وحوارات ولقاءات إذاعية وتلفزيونية على المستوى المحلى والقومى، ورحلات حقلية لطلاب التعليم ما قبل الجامعى و الجامعى وكذلك للمواطنين والموظفين فى الهيئات التى تلعب دوراً فى إدارة شئون البحيرة.

يقترح أيضاً حماية بعض المواقع التى تحتوى على أنواع نادرة أو مهددة بالإنقراض حماية كاملة عن طريق عمل أسيجة أو بأى وسيلة أخرى مثل جزيرتى الكوم الأخضر ودشيمى وقطاع من الحاجز الرملى الذى يفصل البحيرة عن البحر. ومن المهم أيضاً اجراء عملية رصد طويل الأمد للأنواع المتوطنة والنادرة والجديرة بالاهتمام مما يساعد فى إدارة عملية صون هذه الأنواع، وكذلك التحكم فى انتشار الأنواع الغازية.

يعتقد أن نبات البوص هو أكثر نباتات كاسيات البذور انتشارا فى العالم. وهـو نبـات قصـبى معمر له نصول ورقية عريضه مفلطحة ونورات طرفية كبيرة . يتكاثر هـذا النبـات خضـريا ولـه مجموع ريزومى قوى ومتفرع يجرى سريعا فى الأراضى المغمورة بالماء أو الأراضى الجافة ليحتل مساحات جديدة . يغزو هذا النبات العديد من المجارى المائية وأراضى المراعى والأراضى الزراعية، ولكنه ذو فوائد متعددة مثل كونه ملاذا هاما للحياة البرية واستخدامه فى عمـل العشـش والتسـقيف ، وكغذاء للحيوانات ، ووقود ، واستخراج مواد كميائية ومخصبات وكمعالج لتنقية المياة الملوثة (مرشح حيوى) ومادة خام لصناعة الورق.

أظهرت نتائج تقدير المحصول القائم للأجزاء الخضرية لنبات البوص فى بحيرة البـرلس (جم مادة جافة / م^{2}) قيم أعلى عند نهاية الموسم فى شهر أكتوبر ، وفى النواحى الشرقية والجنوبيـة من البحيرة مقارنة بالنواحى الغربية والشمالية . كما كان المحصول القائم للمواقع حديثة العمـر أقـل بكثير من المواقع القديمة . وقد أظهرت نتائج تحليل صور الأقمـار الصـناعية أن مسـاحة البحيـرة تناقصت من ١١١٦٠٨ فدان (=٤٨٨٧٦ هكتار) فى عـام ١٩٨٨ الـى ١٠٠٠٠٠ فـدان (=٤٢٠٠٠ هكتار) فى عام ١٩٩٨ (معدل النقص = ١٠,٦ ٪) ، وفى نفس الوقت تناقصت المساحة المنتشر فيهـا نبات البوص من ٢٨٨٠٠ فدان (=١٠٤١٦ هكتار) الى ١٦٦٠٠ فدان (=٦٩٧٢ هكتار) والتى تمثـل ١٦,٦ ٪ من المساحة الكلية للبحيرة (معدل النقص = ٣٣,١ ٪) . وبناءا على هذه النتائج قدرت الكتلة العظمى للمحصول القائم فى البحيرة ككل بحوالى ٢٣٩٠٤٠ طن مادة جافة، منها ١٧٠٩٨٠ طن تمثل الجزء فوق سطح الماء ، و٦٨٠٦٠ طن تمثل الجزء المغمور من منطقة الاتصال بالريزومات حتـى سطح الماء. دلت نتائج تحليل المكونات العضوية وغير العضوية وتقدير القيم الغذائية على أن الأجزاء الخضراء من المجموع الخضرى القائم تعتبر علفاً أخضراً جيداً بل ممتازاً خاصة فى موسـم الربيـع. ومن حسن الحظ أن العناصر الصغرى (النادرة) تتراكم فى الأجزاء الجافة من النبات أكثر من تراكمها فى الأجزاء الخضراء ، وأن قيم معظم العناصر الكبرى والصغرى تقع ضمن المـدى التـى تتحملـه الحيوانات الرعوية مثل الأغنام والماعز والماشية .

يعتبر الحرث العميق متبوعا بالعزق باستخدام آلات برمائية هو الطريقة المثلى لمقاومـة هـذا النبات . كما يعتبر قطع النبات تحت مستوى سطح الماء وسيلة فعالة أيضا لمقاومتة. ومـع ذلـك اذا أخذنا فى الإعتبار نتائج تحليل صور الأقمار الصناعية وفوائد نبات البوص كملاذ هام للحياة البريـة ، لأمكننا القول أن درجة غزو هذا النبات للبحيرة ليست خطيرة . ولكن فى بعض الأماكن سوف يـؤدى هذا الغزو الى تقسيم البحيرة الى أربعة أحواض منعزلة : حوض واحد فى كل من الجهتـين الشـرقية والغربية، واثنان فى الوسط ، ولذا نقترح الإزالة الجزئية للبوص فى المناطق الضيقة (كما هو الحـال فى الجانب الغربى) ، وكذلك بين الجزر المبعثرة داخل البحيرة (كما هو الحال فى الأجزاء الوسـطى

والشرقية). كما نقترح أيضاً إزالة البوص من المناطق الملاصقة للشاطيء الجنوبى الشــرقى للبحيــرة لمسافة لاتقل عن ١٠٠م داخل الماء حتى نمنع عملية الالتحام الدائم لهذا الجزء من البحيرة بالأرض .

من المحتمل أن يكون التعاقب النباتى قديماً قد حدث كما يلى: قبل ترسب التربة عنــد عمــق ٣٠ م ، كانت منطقة البرلس خاصة ، وشمال الدلتا عامة ، جزء من البحر المتوسط. بعد ذلك تقهقــر البحر شمالاً وبدأ ماء النيل فى الوصول الى هذه المنطقة ، ثم بدأت النباتات المائيــة والرطبــة فــى الظهور وتكون عدد محدود من البحيرات الضحلة (اللاجونات). ومنــذ حــوالى ٢٠٠٠٠ عــام مــن المحتمل أنه حدث إنسداد للنيل مصحوباً بسقوط أمطار غزيرة شمال مصــر ممــا أدى إلــى انتشــار المستنقعات فى كل المنطقة والتى أصبحت مغطاه بنبات البردى. وقد يكون أعقب ذلك برودة أدت إلى ظهور نباتات مثل أشجار التامول والألنس. ثم تلى ذلك قلة تساقط الأمطار وتقلص المستنقعات بســبب الزيادة الكبيرة فى رواسب النهر أثناء مرحلة التعرية ، وبالتالى بدأت النباتات الأرضية فى الإزدهار. ويحتمل حدوث تقلبات فى مياه الجريان السطحى للنهر ووفرة النباتات البرية مع ارتفاع مستوى سطح البحر ، والذى يمكن أن يرجع إلى تغيرات فى كمية الإشعاع الشمسى. أما الصــورة الأخيــرة لهــذا التعاقب فكانت تقهقر المستنقعات بشكل كبير واستقرار عمليــة استصــلاح وزراعــة الأرض نتيجــة للترسيب المستمر للنهر.

٥- الطافيات النباتية

يعتبر مجتمع الطافيات النباتية فى بحيرة البرلس مجتمعاً غنياً من ناحية الكثافة والتنوع، ولكن معظم الأنواع الطحلبية بها من أنواع المياة العذبة او المياة المختلطة. دلت الدراســات الســابقة علــى الطافيات النباتية فى بحيرة البرلس على التباين الكبير فى كثافتها وتركيبها النوعى بناءاً على المحطات التى أخذت منها العينات، والأحوال البيئية، ونوعية المياة ومقدار تلوثها. يصل العدد الكلــى للأنــواع الطحلبية التى سجلت فى البحيرة الى ٢٧٦ نوعاً موزعة كالتالى: ١٤٥ ديــاتوم (٥٥.٣٪ مــن العــدد الكلى) ، ٧٣ طحلب أخضر (٢٦٪)، ٥١ طحلب أزرق (١٨.٦٪)، ١٠ أنواع تنتمى الى مجموعــات أخرى (٣.٦٪).

تمثل الدياتومات الجزء الأكبر من الكتلة الحية للطافيات النباتية فى البحيرة بنسبة تصــل الــى ٦٩٪ ، على الرغم من أنها تشكل حوالى ٣١٪ من العدد الكلى. وعلى الجانب الآخر، تأتى الطحالــب الخضراء فى المرتبة الثانية من حيث مشاركتها فى الكتلة الحية الكلية بنسبة تقل كثيــراً عــن نســبة مشاركة الدياتومات (حوالى ١٦.٢٪)، مع أنها تشكل المشاركة الأكبر من حيث العدد بنسبة تصل الى ٥٨.٩٪. أما الطحالب الزرقاء فتشكل ١٤.٨٪ من الكتلة الحية الكليــة و ٨.٨٪ مــن العــدد الكلــى. وعموماً فإن كتلة وعدد الطحالب أعلى ما يكون فى الجزء الغربى من البحيرة، وأقل مــا يكــون فــى الجزء الشرقى.

دل التباين الزمنى فى الكتلة الحية على أن أعلى قيمة تحققت فى بداية الخريف (سبتمبر) فـــى شرق ووسط البحيرة، مع وجود قيمة عالية نسبياً خلال الشتاء (فبراير) فى الجزء الشـــرقى، والربيـــع (مارس) فى وسط البحيرة. أما فى الجزء الغربى فكانت أعلى قيمة للكتلة الحية فى الصيف (يونيـــو)، بالاضافة الى قيم عليا خلال سبتمبر وديسمبر. وعموماً فإن نمط التغير الشهرى فـــى الكتلـــة الحيـــة للمجموعات الطحلبية الرئيسية (الدياتومات والخضراء والزرقاء) على مدار العام متقـــارب الـــى حـــد كبير.

دراسة المجتمعات الطحلبية العالقة على النباتات المائية مهم جداً لتحديد دورهـــا فـــى الإنتـــاج العضوى فى البحيرات التى تتواجد بها. وفى بحيرة البرلس يمثل نبات حامول الماء حوالى ٨٥٪ مـــن كتلة النباتات المائية المغمورة. وقد دلت الدراسات السابقة على وجود ٤٥ نوعاً طحلبياً تعلق على هذا النبات المائى، ومعظمها يستطيع أن يعيش طافياً أيضاً. تتوزع هذه الأنواع بين المجموعات الطحلبيـــة المختلفة كما يلى: ٢٧ دياتوم، ١٥ طحلب أخضر، ١٢ طحلب أزرق وطحلب أحمر. وعمومـــاً فـــأن انتشار النباتات المائية بالبحيرة وخاصة حامول الماء جعل البحيرة تميل إلى الوسطية الغذائية بـــالنظر إلى إنتاجيتها من الطافيات النباتية.

دلت المقارنة بين مجتمعات الطافيات النباتية فى تسع من بحيرات شمال أفريقيا (٣ بحيرات فى كل من مصر وتونس والمغرب) على أن مجتمعات بحيرات شمال مصر الثلاث (المنزلة ، البـــرلس ، وادكو)، والتى تشكل مواقع قلوية ذات ملوحة أقل من ٢ جرام/لتر ، تتكون من أنواع طحلبية عالميـــة التوزيع وذات كثافات ووفرة نوعية أعلى من البحيرات الأخرى. وتأتى بحيرة البرلس فـــى المقدمـــة حيث أنها ذات الكثافات والوفرة النوعية الأعلى من كل البحيرات الأخرى ، فقد سجل بها ٤٣ نوعـــاً ، على الرغم من أن هذا الرقم يقل كثيراً عن الرقم المسجل فى الدراسات السابقة (٢٢٦ نوعاً).

٦- البكتيريا والفطريات

الدراسات التى أجريت على البكتيريا والفطريات فى بحيرة البرلس محدودة جداً. ففـــى عـــام ٢٠٠٣ أجريت دراسة موسمية على توزيع بعض مجموعات الأكتينوميسيتات فى بحيرة البرلس حيـــث تباين التنوع والكثافة لهذه المجموعات مع التغيرات الموسمية. وقد أثبتت الدراســـة أن توزيـــع هـــذه المجموعات يتأثر ببعض العوامل البيئية مثل الحرارة والمادة العضوية وطبيعة الرواسب. وفـــى عـــام ٢٠٠٤ أجريت دراسة على تنوع الفطريات حيوانية الجراثيم فى طبقة الماء الســـطحى لأربعـــة مـــن البحيرات المصرية: البرلس والمنزلة فى الشمال ، وقارون فى الوسط وناصر فى الجنوب. تم تسجيل ٣٦ نوع بالإضافة إلى ٤ أنواع غير محددة وسلالة واحدة تنتمى جميعاً إلى ١١ جنس من الفطريـــات حيوانية الجراثيم. أثبتت هذه الدراسة أن بحيرة البرلس تأتى فى المرتبة الثانية (بعد بحيرة المنزلة) من

حيث التنوع ، حيث تم تسجيل ١٤ نوعاً بالإضافة إلى ثلاثة أنواع غير محددة وسلالة واحدة تنتمي جميعاً إلى ٩ أجناس.

٧. الهائمات الحيوانية

تم التعرف على ٤٨ نوع من هذه الهائمات في مياه البحيرة عامى ٢٠٠٢/٢٠٠١، تنتمي إلى ثلاث مجموعات وهي العجليات، مجدافية الأرجل ، ومتفرعات القرون . والجدير بالملاحظة أن كل الأنواع التي سجلت من هائمات المياه العذبة . وبمقارنة ما تم تسجيله فى هذه الدراسة مع ما تم تعريفه في السبعينيات نجد أن ١٠ أنواع من الهائمات البحرية قد أختفت، بينما ظهر ١٨ نوع من هائمات المياه العذبة لم تسجل من قبل في البحيرة . وهذا يدل علي الانخفاض الملحوظ في درجة ملوحة مياه البحيرة ، وسيادة مياه الصرف العذبة علي بيئة البحيرة خلال العقدين السابقين .

وقد شكلت العجليات كثافة عالية في كل المحطات تمثل ٧٣.٥ ٪ من العدد الكلي للهائمات الحيوانية ووصل عدد الأنواع فيها إلى ٣٤ نوع. أما مجدافية الأرجل ومتفرعات القرون فقد وصل عدد الأنواع إلى ٧ في كل منها وقد وصلت كثافة الهائمات الحيوانية أعلى قيمة لها في الجزء الغربي من البحيرة بمتوسط ١٧٦٤٣٣٣ فرد م$^{-٣}$. أما أقل قيمة لها كانت ٣٩٥٠٠٠ فرد م$^{-٣}$ في الجزء الشرقى، وعلى حسب تنوع الفصول لوحظت زيادة تدريجية في المحصول القائم للهائمات الحيوانية من ٥٢٣٣٠٠ فرد م$^{-٣}$ في الخريف إلى ١٣٥٣١٨٢ فرد م$^{-٣}$ في الصيف بمتوسط قدره ٩٠٢٩١١ فرد م$^{-٣}$. وفى موسم ٢٠٠٤/٢٠٠٣ تم تسجيل ٧٥ نوعا من الهائمات الحيوانية نتيجة دخول انواع بحرية من البحر المتوسط بعد صيانة البوغاز وعمل بعض القنوات الشعاعية لزيادة كمية المياه المالحة التى تدخل البحيرة.

تعتبر مجموعة العجليات أكثر المجموعات انتشاراً حيث بلغ متوسط أعلى كثافة لها ١٥٧٧٦٧٧ فرد م$^{-٣}$ في الجزء الغربى من البحيرة في الصيف، وانخفض المحصول القائم إلى ١٩٨٠٠٠ فرد م$^{-٣}$ في الجزء الشرقى. ويعتبر فصل الصيف الأعلى إنتاجاً بمتوسط ١١٦٦٢٧٣ فرد م$^{-٣}$ في المحصول القائم لهذه المجموعة، بينما فصل الخريف كان الأقل إنتاجاً بمتوسط ٣٠٧٨٠٠ فرد م$^{-٣}$. أما مجموعة مجدافية الأرجل فبلغ أعلى كثافة لها ١٠٦٠٠٠٠ فرد م$^{-٣}$ في الربيع، ويعود ذلك إلى ازدهار وتكاثر هذه الانواع فى هذا الفصل، وقد انخفض المحصول القائم إلى أقل قيمة (٢٩٠٠٠ فرد م$^{-٣}$) في فصل الخريف. أما مجموعة متفرعات القرون فبلغ متوسط كثافتها أعلى قيمة في الصيف ٢١٠٠٠٠ فرد م$^{-٣}$ ، ويعتبر فصل الشتاء أفقر الفصول في انتشار هذه المجموعة .

٨. القاعيات الحيوانية

تم تسجيل ٣٣ نوعاً من الكائنات القاعية في بحيرة البرلس خلال عامى ٢٠٠٢/٢٠٠١، وهي تنتمي إلى ثلاث مجموعات هي: المفصليات ، الرخويات ، والديدان الحلقية. وقد مثلت المفصليات ١٣

نوع والرخويات ١٢ نوع والديدان الحلقية ٨ أنواع. وقد وصلت متوسط كثافة القاعيات الحيوانية أعلى قيمة لها ٤٨٠٠ فرد م$^{-3}$ ، أما متوسط أقل قيمة للمحصول القائم فهو ١٣٨٠ فرد م$^{-3}$. أما موسمياً فقد لوحظ زيادة تدريجية في المحصول القائم وكان متوسط أقل قيمة ١٣٣٨ فرد م$^{-3}$ بوزن ١٦.١١ جم م$^{-2}$ في الشتاء، ومتوسط أعلى قيمة ٥٦٤٦ فرد م$^{-3}$ في الربيع بوزن ٢٩.٨٠ جم م$^{-2}$.

تعتبر مجموعة الديدان الحلقية هي أكثر المجموعات انتشاراً حيث بلغت نسبة محصولها القائم ٥٩.٦٪ ، وجاءت مفصلية الأرجل بعدها بنسبة ٣٣.٩ ٪، بينما أتت الرخويات في الترتيب الأخير بنسبة ٦.٥ ٪. أما من جهة الكتلة الحية فقد وصلت كتلة الرخويات إلى ٧١.٨٪ يليها مفصلية الأرجل (١٦.٦ ٪) ثم الديدان الحلقية (١١.٦٪).

أوضحت الدراسة أيضاً انخفاض التنوع البيولوجي للحيوانات القاعية عما كان مسجلاً منذ عقدين وذلك لانخفاض ملوحة البحيرة وزيادة كمية مياه الصرف التي تدخلها بما فيها من مبيدات ومواد عضوية .

٩. الأسماك

تم تسجيل حوالي ٣٣ نوع من الأسماك في بحيرة البرلس أثناء السبعينيات من القرن الماضى ما بين أسماك بحرية ومهاجرة ومياه عذبة ، ولكن في عام ٢٠٠١ تم تسجيل ٢٥ نوع فقط معظمها أسماك مياه عذبة ومهاجرة مؤقتاً . اختفت ٨ أنواع من الأسماك البحرية ، وهو دليل بيولوجي أخر علي سيادة مياه الصرف الزراعي علي بيئة البحيرة ، والأنخفاض الشديد لملوحة البحيرة . ورغم زيادة الإنتاجية الفعلية للبحيرة من الأسماك فإن نوعية الأسماك وحجمها الصغير يقلل كثيراً من القيمة الإنتاجية الفعلية لهذه الأسماك الذي ينعكس بصورة مباشرة علي دخل الصياد .

. وقد زادت إنتاجية الأسماك من بحيرة البرلس خلال العقدين السابقين زيادة كبيرة من ٧٢٧٣ طن في عام ١٩٨٢ إلي ٥٩٠٠٠ طن في عام ٢٠٠٣ . وتعزي هذه الزيادة الكبيرة في الإنتاجية إلي زيادة نسبة المخصبات والعناصر الغذائية التي تدخل البحيرة مع مياه الصرف الزراعي، وذلك بالإضافة إلي زيادة جهد الصيد في البحيرة. .وقد تغير التركيب النوعي للمصيد ايضاً بعد أن كان خليط من الأسماك العذبة والبحرية في الستينيات إلي أسماك مياه عذبة فقط تقريباً. فبعد أن كانت نسبة سمكة البلطي في المصيد الكلي عام ١٩٦٤ حوالي ٤٥٪ فقط أصبح حوالي ٨٥٪ عام ٢٠٠٠ ، وانخفضت انتاجية العائلة البورية من حوالي ٢٠٪ إلي ١٠٪ من المصيد الكلي ، وايضاً أنخفضت مصيد الربيان والسرطان من ٢٥٪ عام ١٩٦٤ إلي أقل من ١٠٪ عام ٢٠٠٠.

١٠. العنكبيات والحشرات

تم دراسة مجموعة العنكبيات لأول مرة في محمية البرلس عام ٢٠٠٠ ، وقد تم تسجيل ٢٣ نوع فقط من العقارب والعناكب وأنواع أخري ، وتحتاج هذه المجموعة دراسة تفصيلية أخري موسمية حتي نستطيع أن نتعرف علي كل الأنواع الممكن تواجدها في هذه المنطقة.

وعلى الجانب الأخر، تم تعريف ٩٥ نوعا من الحشرات تنتمى إلى ٥٩ فصيلة و ١٦ رتبة. ومما لا شك فيه أن تلك الأرقام لا تعبر عن التنوع الحشرى فى منطقة البرلس بسبب قصر مدة الدراسة (شهران فقط). وبناءا على ماسبق فمن الموصى به إجراء مسح شهرى لمدة عامين متتاليين حتى يمكن إعطاء صورة حقيقية عن التنوع الحشرى فى تلك المنطقة.

١١. البرمائيات والزواحف

تم تسجيل ٢٣ نوع من البرمائيات والزواحف في محمية البرلس حتي الأن . من أهم الأنواع التي سجلت هو ضفدع قصاص الذي يعتبر الوحيد ضمن هذه المجموعة المستوطن في مصر ، وهو ينتشر بكثرة في مستنقعات المياه العذبة علي طول الجزء الجنوبي لبحيرة البرلس. وايضاً من الأنواع الجديره بالاهتمام السحلية النعامة ، وهذا النوع مهدد بالانقراض داخل مصر نتيجة تدمير بيئته الطبيعية خصوصاً الكثبان الرملية . وايضاً الدساس البلدي مهدد بالانقراض نتيجة جمعه بكثافة عالية والتجارة فيه كنوع من الحيوانات الأليفة المستأنسة. أما النوعين المهددين بالانقراض عالمياً ، ويجب الاهتمام بها أكثر ووضع بعض البرامج الخاصة للحفاظ عليهما وتنميتهما هما السلحفاه البحرية كبيرة الرأس المسماة الترسه والسلحفاه الخضراء.

١٢. الطيور

دلت الدراسات السابقة التى أجريت على طيور بحيرة البرلس على وجود حوالى ١١٢ نوعاً وتحت نوع تشكل حوالى ٢٢٪ من العدد الكلى للطيور المصرية. ومن الجدير بالذكر أنه خلال أربعة مسوح شتوية أجريت فى الأعوام ١٩٧٨، ١٩٧٩، ١٩٨٩ و ١٩٩٤ على طيور البحيرة لوحظ نقص كبير فى العدد الكلى للطيور مصحوباً بزيادة فى الوفرة النوعية. وقد كان النقص فى العدد الكلى للطيور راجعاً الى النقص الحاد فى أعداد جماعات بعض الأنواع مثل غر، كبش، نورس أسود الرأس ، حمراوى وزرقاوى أخضر. وعلى الجانب الآخر فإن أعداد بعض الجماعات الأخرى قد زادت مع الزمن مثل قطقاط أبو الرؤوس ، كروان الماء ، وصياد السمك الأبقع.

تنقسم طيور البحيرة الى ٤٦ نوعاً مقيماً، و ٨٠ نوعا زائراً فى الشتاء، ٢٣ نوعاً زائراً فى الصيف، و ٧٢ نوعاً عابراً صيفاً وخريفاً. ومن بين هذه الطيور ٨ أنواع وتحت أنواع من الطيور المتوطنة تمثل حوالى ٤٧٪ من العدد الكلى للطيور المصرية المتوطنة والتى يقدر عددها بحوالى ١٧ نوعاً.

ما زالت طيور الماء تصاد فى كل الأراضى الرطبة بمصر، وخاصة بحيرة البرلس. وهنـــاك نوعان من الصيد: الصيد التجارى والصيد الرياضى، وكلاهما يحدث فى الشتاء حين تكون هناك وفرة فى أعداد الطيور. ومن الممارسات التى ليس لها تبرير اقتصادى وتعتبر ممارسات تدميرية هو صـــيد الطيور آكلة الفرائس (الطيور المفترسة). وعموماً فإنه يجب تطبيق بعض الممارسات الإدارية لصون الطيور فى بحيرة البرلس ومنها تفعيل قوانين حماية الأنواع، إجراء برامج توعية شعبية تبين أهميـــة الحفاظ على الحياة البرية عموماً والطيور البرية على وجه الخصوص ، تشجيع سياحة مراقبة الطيور من خلال السياحة البيئية، منع تدمير أو تحوير المواطن التى تأوى إليها الطيور وتفرخ بهـــا، تأســـيس برنامج لحماية الطيور المهددة بالانقراض، وأخيراً مشاركة الهيئات المحلية الحكومية وكذلك الجمعيات والمؤسسات الأهلية فى خطة إدارة البحيرة.

تلعب الطيور المهاجرة دوراً هاماً فى نشر العديد من الكائنات الدقيقة الممرضة ، لـــيس فقـــط للطيور المستأنسة، ولكن للإنسان والحيوان. تم تسجيل تسعة أنواع من الأكاروسات و ٧ أنـــواع مـــن القمل المتطفل على طيور السمان المهاجرة فى منطقة البرلس الرطبة، بينما تم تسجيل ستة أنواع مـــن الأكاروسات و ٤ من القمل المتطفل على سمان المزارع. كان أعلى معدل للإصابة بالأكاروسات خلال شهر نوفمبر للسمان المهاجر وسبتمبر لسمان المزارع. بينما كان أعلى معدل للإضافة بالقمـــل خـــلال شهر اكتوبر للسمان المهاجر، وسبتمبر لسمان المزارع.

١٣. الثدييات

تم التعرف علي حوالي ١٨ نوع من الثدييات في منطقة البرلس حتي الأن . ومن اهمهـــا زباب الزهور وهو مستوطن في مصر ويعتبر نادراً عددياً . كما يوجد نوعين مهـــددين بـــالإنقراض عالمياً هما : أبن آوي والقط البري النيلي.

١٤. النشاط الأجتماعى والاقتصادى

تقع بحيرة البرلس في ٥ مراكز تابعة لمحافظة كفر الشيخ (من الشرق إلي الغرب : بلطـــيم ، الحامول ، الرياض ، سيدي سالم ومطوبس) ، ويقدر عدد سكانها بحوالي ٩٦٥٢٢٠ فـــرد. ويضـــم مركز بلطيم أكبر تجمع سكاني حول البحيرة ، يتركز معظمهم في مدينة بلطيم (٣٧٣٠٠فرد) . هـــذا بالإضافة إلي ١٥ قرية تابعة للخمسة مراكز سابقة الذكر ، التي تقع أجزاء كبيرة منهم داخـــل حـــدود محمية البرلس. وفي عام ١٩٩٦ كان تعداد السكان داخل المحمية حوالي ١٧١٧٠٠ فرد ؛ أرتفع إلي ١٨٨٩٠٠ فرد عام ٢٠٠١ ؛ بمعدل نمو سنوي حوالي ٢٪ . وتعداد الذكور دائماً أعلي مـــن الانـــاث ولكن بنسبة قليلة. وتعتبر نسبة الأمية عاليه بين سكان المحمية ، ولكن دائماً أعلي بين الاناث (٥٧.٥ – ٨٩.٩٪) فى التعداد الكلي لأي قرية أو مدينة (٣٠٪ – ٧٩.٨٪) . وتعتبر نســـبة البطالـــة بـــين

سكان المحمية منخفضة نسبياً (٨.٥ ٪) ، مقارنةً بالمناطق الأخري في محافظة كفر الشيخ ، ولكنها تعتبر عالية بين الأناث (٢٣.٤٪) . وتعتبر نسبة مشاركة المرأة في العمل داخل المحمية منخفضة جداً حيث تصل لحوالي ٦.٧٪ فقط. ومعظم أنشطة سكان المحمية يتركز في صيد الأسماك والطيور ، والزراعة وبعض الصناعات الصغيرة مثل المراكب وصيانتها وصناعة وتصليح بعض المواتير والخدمات الصغيرة الأخري .

يوجد حوالي ١٩٠٠٠ فدان من الأراضي الزراعية داخل حدود المحمية . ولكن تنعدم الزراعة نوعاً ما في الأراضي الملاصقة لشواطئ البحيرة وذلك نتيجة لزيادة ملوحة التربة وفقرها للعناصر الغذائية الهامة ، ولكن مجهودات استصلاح الأراضي مستمرة خصوصاً في الجزء الغربي لفتحة البوغاز حيث أن التربة السائدة هناك رملية . اما الجزء الشرقي للبوغاز بالقرب من بلطيم فهي مزروعة بكثافة عالية بعديد من المحاصيل والخضراوات والفاكهه ولكن أساساً بنخيل البلح وشجر الجوافة . يقوم بعض المزراعين داخل المحمية بتربية البقر والجاموس والماعز والجمال ، وقد قدر العائد المادي السنوي لمزارعى المحمية خلال عام ١٩٩٩ بحوالي ٣٦.٦١١ مليون جنيه مصري . ولكن العائد النهائي للفرد من تربية الماشية يعتبر منخفض نسبياً نتيجة عدد الماشية المملوكة للعائلة الواحدة وأنخفاض إنتاجية القطعان المحلية

تعتمد صناعة السياحة في منطقة البرلس أساساً علي سياحة المصريين أثناء الصيف ، وهي تتركز علي شواطئ البحر بمنطقة بلطيم . ويوجد حوالي ١٦٥ حجرة فندقية فقط في محافظة كفر الشيخ ، لذلك فإن إقامة معظم السائحين يعتمد علي وجود شاليهات علي البحر مباشرة أو الشقق الخاصة لبعض المقيمين في المنطقة. ويخطط مكتب السياحة بالمحافظة حالياً لإنشاء مارينا للسياحة العالمية بالقرب من رشيد وإقامة بعض المنتجعات علي البحر مباشرة بطول الحاجز الرملي . بالإضافة إلي ذلك ، يوجد في منطقة البرلس ٦ مواقع ذات أهمية تاريخية كبيرة ، من الممكن أن تساهم في تنمية السياحة في هذه المنطقة ، خاصة مدينة تل الفراعنة .

تعتبر حرفة الصيد هي النشاط الاقتصادي الرئيسي في منطقة البرلس ، وقد زاد عدد الصيادين في البحيرة من حوالي ٩٠٠٠ صياد عام ١٩٦٣ إلي حوالي ٢٨٠٠٠ صياد عام ٢٠٠٠ ، ولكن عدد الصيادين الذي لديهم رخصة صيد قانونية حوالي ١٠٢٦٦ صياد فقط . أما عدد المراكب المرخصة فقد زادت من ٢٤٣٨ عام ١٩٦٣ إلي حوالي ١٠٤٨٩ في عام ٢٠٠٠ ، منها ١٥٣ مركب فقط تعمل بالموتور. في عام ٢٠٠١ كانت أنتاجية البحيرة حوالي ٥٩٠٠٠ طن ، وقد قدر ثمن الطن بحوالي ٤٥٠٠ – ٥٠٠٠ جنيه مصري ، ولذلك فإن العائد الكلي للمصيد في العام الواحد قدر بحوالي ٢٥٦.٥ – ٢٨٥ مليون جنيه مصري .

يعتبر نظام الحوش أحد طرائق الصيد المخالفة للقانون ؛ حيث تقضي هذه الطريقة علي كميات كبيرة من صغار الأسماك . في عام ١٩٨٢ كان عدد الحوش المصرح بها ١٧١ حوشه تغطي حوالي

١٢٦٨٩ هكتار من مساحة البحيرة ، بالإضافة إلي ١٠٧٩ حوشه غير مرخصة تغطي حوالي ٤٨٣٣ هكتار . ولكن في العقد الأخير تم إلغاء كل التراخيص الخاصة بهذه الحوش ، وأن كان مازال كثير منها يعمل بصفة غير قانونية وذلك لعائدها الكبير .

زاد نشاط الاستزراع السمكي في العقدين الأخيرين علي طول الشاطئ الجنوبي لبحيرة البرلس . وقد أنشئت هذه المزارع السمكية علي الأرض البورغير الصالحة للزراعة . وتقدر مساحة الأراضي التي بها هذا النشاط بحوالي ١٣٤٦ هكتار تنتج تقريباً حوالي ١١٥٣٣٥ طن سنوياً ، وهي إنتاجية كبيرة إذا قورنت بإنتاجية البحيرة ، ويستحق هذا النشاط دراسة متأنية علي مدي تأثيره البيئي والاقتصادي علي البحيرة ، خصوصاً أن الشكوي العامة من الصيادين هو حصول هذه المزارع علي زريعة أسماك العائلة البورية بطريقة غير قانونية من منطقة بوغاز البحيرة ، وهذا بالتأكيد يحرم البحيرة والصيادين من كميات كبيرة لأسماك البوري الذي تدهور أنتاجه في الفترة الأخيرة بشكل كبير.

تعتبر مهنة صيد الطيور من أوسع الأنشطة في منطقة البرلس ، خصوصاً صيد السمان في فصل الخريف ، وصيد الطيور المائية وفي فصل الشتاء. وبرغم من أن جميع أشكال الصيد ممنوعة تماماً حالياً بعد اعلان منطقة البرلس محمية طبيعية ، لكنها مازالت مستمرة بصور مختلفة وان كانت أقل من الماضي . فمن شهر أكتوبر حتي ديسمبر تثبت أنواع مختلفة من الشباك أمام الحاجز الرملي بالقرب من مياه البحر المتوسط وذلك لصيد السمان . وفي فصل الشتاء تستخدم البنادق وبعض أنواع من الشباك الصغيرة لصيد الطيور المائية . وغالباً ما تباع هذه الطيور في أقرب المدن الكبيرة مثل رشيد والإسكندرية بأسعار عالية نسبياً .

تقطع كميات كبيرة من نباتات البوص *Phragmites australis* من البحيرة وتستخدم في كثير من الأغراض . فالسيقان الخضراء تستخدم كعلف لكثير من الحيوانات . أما الجافة فتستخدم كمواد بناء ومصدات للرياح ، وشباك صيد للأسماك أو الطيور ، ووقود. لم تجري حتي الأن أية دراسات أقتصادية تفصيلية عن هذا النشاط في منطقة البرلس أو حتي علي تأثيراتها البيئية علي الكائنات الأخري في البحيرة .

١٥- خطة ادارة محمية البرلس

تم اختيار منطقة البرلس لوضع خطة إدارة لها من قبل مجموعة العمل الوطنية التي تأسست من خلال مشروع صون الأراضي الرطبة والمناطق الساحلية في حوض البحر المتوسط – وذلك لعدة أسباب : أ – أهمية البحيرة كموقع فريد لتكاثر وهجرة الطيور المائية ، سواء علي المستوى المحلى أو العالمي، ب– تنوعها الحيوي الكبير الذي يشمل أكثر من ٧٠٠ نوع معروف حتى الآن ، منها ١١ نوعاً مستوطناً في مصر و٧ أنواع مهددة بالانقراض عالمياً ، ج– أقل بحيرات دلتا النيل تلوثاً ، وهي

أول البحيرات الشمالية من حيث إنتاجية الثروة السمكية الذي يصل إلي حوالي ٥٩ ألف طن سنوياً ، و د – وجود كثير من التهديدات والمشاكل في منطقة البرلس.

وبعد الدراسات الحقلية التفصيلية عن خصائص ومميزات المحمية ، وإحتياجاتها ، والمشاكل والمعوقات التي تواجها، تم تقييم المحمية أجتماعيا واقتصاديا و بيئيا من حيث التنوع الحيوى، الندرة،الهشاشة البيئية، والنموذجية. ثم تم وضع الأهداف الأساسية طويلة الأمد في خطة إدارة المحمية، وهى: ١– أستعادة المميزات البيئية والجمالية التي دمرت في المحمية ، ٢– صون وتحسين البيئات الطبيعية بالمحمية ، ٣– المحافظة علي الثراوات الطبيعية بالمحمية من خلال الإدارة المستدامة ، ٤– تحسين الجوانب الإقتصادية والإجتماعية للإفراد المقيمين بالمحمية ، و ٥– رفع مستوي الوعي البيئي بأهمية صون الطبيعة.

ولتحقيق أى هدف أساسي لابد من وضع بعض الأهداف العملية التي يمكن تطبيقها علي المدى القصير ، يمكن قياسها ومتابعتها عن طريق برنامج رصدي . ومن أجل إنجاز كل هدف عملي لابد من تحديد بعض المشاريع الصغيرة التي في النهاية تحقق هدف أو أكثر. وبناءاً على ما سبق تم تحديد الأهداف العملية التالية :

أستعادة المميزات البيئية والجمالية التي دمرت في المحمية

١) أستعادة مستوي ملوحة مياه البحيرة
٢) تصميم برنامج رصدي لنوعية وكمية المياه
٣) معالجة المياه لإعادة أستخدامها
٤) رصد التغيرات المناخية

صون وتحسين البيئات الطبيعية بالمحمية

١) الأخذ بنظام التمنطق (تقسيم المحمية إلي مناطق)
٢) وضع برنامج داخلي لقياس وتقييم صون الأنواع
٣) وضع برنامج خارجى لقياس وتقييم صون الأنواع
٤) وضع نظام لإدارة المعلومات
٥) رصد التنوع الحيوي
٦) وضع برنامج بحثي

المحافظة علي الثروات الطبيعية بالمحمية من خلال الإدارة المستدامة

١) تفعيل تنفيذ القانون بالقوة
٢) مراجعة التشريعات والقوانين
٣) الأستخدام الأمثل المستدام للثروة السمكية
٤) الاستخدام الأمثل المستدام لنمو البوص في البحيرة

تحسين الجوانب الإقتصادية والإجتماعية للأفراد المقيمين بالمحمية

١) بناء ورفع القدرات في شتي المجالات

٢) تنمية السياحة البيئية

٣) رفع القدرة علي زيادة التمويل المالي

رفع مستوي الوعي البيئي بأهمية صون الطبيعية

١) رفع مستوي الوعي العام

٢) تحفيذ وتفعيل البرامج الوطنية العامة

وبعد تحديد الأهداف العملية كانت الخطوة التالية هى وضع المشاريع التي تحقق هذه الأهداف والطرائق المختلفة الملائمة لتنفيذها. وتم تقسيم المحمية إلي مناطق مختلفة تساعد كثيـراً فـي حمايـة المناطق الحساسة الهامة ، وفي وضع القواعد والقوانين المنظمة للأنشطة داخل هذه المناطق ، وأيضا تساعد مسئولي المحمية عند التطبيق الواقعي لخطة الإدارة . كما تم تشـكيل لجنـة لإدارة المحميـة برئاسة محافظ كفر الشيخ (الإقليم الذى تنتمى اليه بحيرة البرلس) وعضوية ممثلين من جميع الوزارات والهيئات المتواجـدة بمنطقـة البـرلس وذلـك لمتابعـة تطبيـق مشـاريع خطـة ادارة المحميـة.

رئاسة مجلس الوزراء
جهـــاز شـــــئون البيـــئة
ادارة المحميات الطبيعية

بحيرة البرلس:
محمية البرلس الطبيعية

دكتور/ كمال حسين شلتوت
أستاذ البيئة النباتية
كلية العلوم – جامعةطنطا

دكتور/ مجدى توفيق خليل
أستاذ البيئة المائية
كلية العلوم – جامعة عين شمس

مطبوعات وحدة التنوع البيولوجى – العدد ١٣ – ٢٠٠٥

رئاسة مجلس الوزراء
جهـــاز شـــئون البيـــئة
ادارة المحميات الطبيعية

بحيرة البرلس:
محمية البرلس الطبيعية

دكتور/ كمال حسين شلتوت
كلية العلوم – جامعةطنطا

دكتور/ مجدى توفيق خليل
كلية العلوم – جامعة عين شمس

بمشاركة من

دكتور/ يس محمد السودانى
كلية التربية بكفر الشيخ- جامعة طنطا

مطبوعات وحدة التنوع البيولوجى – العدد ١٣ – ٢٠٠٥

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Teaching Experience: Teaching under graduate courses such as General Botany, Structure & Function of Ecosystems, Vegetation Ecology, Wild Life Conservation, Phytogeography, Flora, Economic Botany, Environmental Pollution and Taxonomy of Flowering Plants, and post graduate courses such as Methods of Vegetation Analysis, Population Ecology, Phytosociology, and Biostatistics.

Fields of Research Experience: Analysis, biodiversity, population ecology and conservation of the vegetation of the Mediterranean and Saharo-Arabian regions (including arid and wetlands) with special emphasis on the Egyptian and Arabian environments.

Projects: Working as research assistant, researcher and team leader in many research projects that have been carried out in the Egyptian desert and wetland ecosystems since 1975 up till now.

Trainings, Scholarships and Scientific Meetings: Attending many training courses and scholarships in Egypt, Saudi Arabia, Kenya, France and the Netherlands, as well as several national and international symposia, conferences and congresses in Egypt and abroad.

Scientific School: 24 M.Sc.'s and Ph.D.'s in the fields of population and community phytoecology.

Councils, Committees and Societies: Member of 19 national and international councils, committees and societies in the field of Botany and Environmental Sciences.

Publications: Seventy publications, in national and international specialized journals, covering many aspects of plant ecology such as:

a) Population ecology of Thymelaea hirsuta, a circum Mediterranean shrub of great environmental and ecomomic importance.

b) Population and vegetation ecology of the Nile Delta region, the region that has been subjected to severe environmental impact after the construction of Aswan High Dam.

c) Analysis and management of the vegetation of the Eastern and Central Saudi Arabia.

d) The primary production and diversity of the vegetation of the western Mediterranean desert of Egypt.

e) Population and vegetation ecology of the Egyptian Red Sea and eastern deserts.

f) Scientific culture, environmental awareness, environmental education and community services.

Honours and Awards:

a) State Award in Biological Sciences, from the Egyptian Academy of Scientific Research and Technology (1996).

b) First Order of Excellence, from the President of Egypt (1997)

c) Biographee in WHO'S WHO in Science and Engineering & WHO'S WHO in the World

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Present Occupation: **Professor of Aquatic Ecology,**
Zoology Department, Faculty of Science, Ain Shams University.

Degrees

- **Ph. D. in 1985, from Syracuse University, N.Y., USA and Ain Shams University, joint supervision.**
- **M. Sc. in 1978, from Ain Shams University.**
- **B. Sc. in 1973, from Zoology Dept., Faculty of Science, Ain Shams University.**

Field of Research: **Environmental Sciences, Aquatic Ecology & Biodiversity.**

Published Articles: **Over 40 papers in international and local journals in the above fields.**

Supervision of Theses: **Supervised more than 27 theses for M.Sc. and Ph.D. in the above fields.**

Membership of Societies and Organizations

Active member in 12 Scientific international and local societies such as the Ecological Society of America, USA; International Center for Living Aquatic Resources Management, Philippines; the National Committee of Environmental Affairs, Egyptian Academy of Science and Technology.

Projects

Co- researcher of 14 scientific projects such as the Egyptian - American project for developing Lake Qarun (1973-1978); Development of Lake Manzala, under the supervision of UNEP and a Canadian company (1979-1980); American project for investigating the water quality and the effect of the industrial wastes upon three rivers system in Central New York, USA (1981); the effects of pollutants upon fauna of Lakes Manzala and Maruit (1987 - 1988); a project for preparing "Egypt Country Study on Biological Diversity", Egyptian Environmental Affairs Agency (1993-1994) with UNEP support. Through this project 8 detailed studies on species diversity of 8 taxa of freshwater organisms have been prepared. Moreover, 8 volumes on "Habitat Diversity of Coastal Lagoons and Inland Lakes" have been prepared. Also, he author joined a project for studying the Biodiversity at Gulf of Aqaba, under the supervision of Natural Protectorates Department of EEAA (1994-1995). Joined a project supported by Operational Unit for Development Assistance (OUDA) through Consulting Engineers Services for biological treatment some of wastewater discharging into Lake Manzala and reusing it in agriculture and fish culture (2000 -2005). Joined a Project for the Conservation of Wetland and Coastal Ecosystems in the Mediterranean Region as a National Coordinator of descriptive studies of 3 protectorates (Burullus, Bardawil, Omayed) , from May 2001 until 2005.

Scientific Books

Contributed in producing 3 reference books for the National Biodiversity Unit of EEAA:

1. **Freshwater Fishes of Egypt (1997).**
2. **Freshwater Molluscs of Egypt (1998).**
3. **Lake Nasser (2001).**

Awards & Certificates

1- The State-Encouragement Prize in Biology (Environmental Studies) in 1998.
2- Medal and Certificate of Appreciation from Ain Shams University in 2000.
3- Certificate of Merit as Environmental Patron from the Arab Towns Organization, Doha, Qatar in 2001